THE JOURNAL OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

· JULY · 1915 ·

DO YOU READ THE JOURNAL?

THE Conference of Local Sections at the Spring Meeting developed the fact that many members have not kept informed on Society activities through reading The Journal.

Not all members know—

THAT they have a voice in the election of new members.

THAT they may obtain complete copies of the professional record of every applicant. All applications are posted in The Journal.

THAT information regarding candidates is solicited and when received is strictly confidential and is carefully considered before further action is taken on the application reviewed. (This announcement is made each month at the head of the list of applicants posted.)

THAT every applicant for membership applies either because he seeks such affiliation of his own volition, or because some member has invited him to apply. Invitations to join are never officially issued by the Society.

THAT the annual Transactions will be distributed as usual this summer, and that the size of volume will remain the same.

THAT a digest of Council meetings is printed regularly in The Journal.

THAT a Financial Report is published annually in The Journal and will be furnished in detail to any member at any time.

THAT Local Sections are fostered in every way by the Society.

A few moments' perusal of this and the preliminary pages of each month's Journal will enhance the value of membership.

Total Membership of the Society, June 25, 1915 6,413
New Members since January 1, 1915 311

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THE SPRING MEETING

THE Spring Meeting of the Society at Buffalo, N. Y., the first meeting of the Society to be held in Buffalo, was a decided success. The meeting opened on Tuesday, June 22, and closed on Friday, June 25, with headquarters at Hotel Statler. There were 223 members registered and 201 guests, a total attendance of 424, and the figures would probably have gone even higher had it not been for the unexpectedly cold weather on Wednesday. On Thursday a party of fifty came from Cleveland by boat.

The local committees had made most complete, and even elaborate, preparations for the reception of the guests. During the time of the meeting many of the committee members were in constant attendance, and nothing was left undone that could in any way contribute to the pleasure of those who were present. The chairmen of the several local committees were the following: General Committee, David Bell; Finance Committee, D. W. Sowers; Reception Committee, H. P. Parrock; Entertainment Committee, David C. Howard; Women's Committee, Mrs. William Henry Barr; Hotel Committee, W. H. Carrier; Printing and Publicity Committee, John Younger.

A great deal of interest was shown in the technical excursions to industrial plants in Buffalo, many of which opened their doors freely to the visitors. Niagara also contributed its share of interesting features, and the Reception, Entertainment and Women's Committees were at all times ready to provide some form of entertainment. In spite of these many social attractions, however, the meeting was very obviously one of serious purpose where attendance at professional sessions and consideration of committee activities were made matters of the first importance.

There were four professional sessions arranged by the Committee on Meetings, John H. Barr, Chairman. These were held in the ball room and a private dining room of the hotel, except on Wednesday morning, when all went to Niagara Falls for the day, and met for the business meeting and a professional session in the auditorium of the Shredded Wheat Company's factory.

Four important committee meetings were held during the convention, as follows: the Research Committee, the Local Sections Committee, the Boiler Code Committee, and the Increase of Membership Committee. The Local Sections Committee was well represented by delegates from the local sections in all parts of the country, and three sessions were held. Similarly, the Boiler Code Committee and the Increase of Membership Committee held important meetings of two sessions each. Accounts of these meetings appear elsewhere in this issue.

The headquarters were opened in the hotel for registration at 2 o'clock on Tuesday. Many took early advantage of this, and the registration on the first day amounted to over 150. At 4 o'clock a meeting of the Research Committee was held, and at 6 o'clock a conference and dinner of officers and representatives of local sections, with the Local Sections Committee. This dinner proved to be of considerable importance in connection with the development of their work.

TUESDAY EVENING'S RECEPTION

On Tuesday evening, the party gathered in the ball room of the Hotel Statler for the informal reception by the members of the Engineering Society of Buffalo and local members of The American Society of Mechanical Engineers. Chairman David Bell, of the local committee, opened the exercises by introducing Mr. Frank B. Baird of Buffalo, who warmly welcomed the engineering guests. He said in part:

Before formally welcoming our visitors, let us ask Who are these people and why welcome them? Our visitors are a clan of dreamers whose dreams come true. They study to control those wonderful forces of nature which have attracted man for ages. First viewed with awe and superstition, these forces were afterwards studied in that process of evolution which is thousands of years old and still in its infancy.

Primitive man, sensing that he could drag a larger load than he could carry, built a sled in a cold climate, rollers in a warmer climate. Then came the first mechanical engineer, the man who first used the wheel and axle. We do not know his color, his skull long is dust, but his idea lives in the principle of locomotion. Were he here today he would be greeted as a hero.

The speaker referred to Jules Verne, the Frenchman who wished to be an engineer but was forced instead to be a

lawyer, yet who dreamed of conquering the forces of nature. Some things in his stories, designed to make them attractive, should be excused; but now, fifty years after they were written, his dreams are coming true. He referred also to John Fritz, the great mechanical engineer, who, when steel shafts of greater strength were demanded conceived and built the hollow axle.

He told of Dr. Brashear's remarkable astronomical instruments. The naked eye counts eight to twelve stars within the ten-degree angle of the lens used in stellar photography but the photograph itself, less than one foot square, will divulge more than 200,000 stars. We are only on the threshold of research, the benefits of which will come to us and our children. It is hard to conceive of the vastness of the dreams of the mechanical engineer. Hundreds of broad gauge men are at work on the problems of nature and science. These are the type of people we are to welcome and Buffalo is proud to receive them.

REMARKS BY PRESIDENT BRASHEAR

Dr. John A. Brashear responded for the Society, beginning his remarks with an observation on the general ignorance of the wonders accomplished in the engineering world, and told, to illustrate this, to the merriment of the audience, some stories of the astonishment among the negroes of the South at the time of the Atlanta expedition to observe the eclipse of 1900.

To illustrate the remarkable advances in science and engineering, Dr. Brashear said:

I have talked with the woman who sat for the first photograph ever made in America. She was 84 years old when I knew her. The photograph was taken the year before I was born, 1839. The photograph was a daguerreotype. She had to sit still in a chair for an hour with her face covered with white powder and her eyes closed. Three great mirrors on the roof of a building were throwing light on her all the time. The picture was perfect. Today the same result is achieved in a tenth of a second.

He further continued: I have an apparatus in Pittsburgh which photographs and records the actual flight of a cannon ball or a shell from the mouth of a cannon. It will record that flight for a foot or for a mile. By that means, we determine accurately the speed of the projectile and the vibrations of the gun itself, as high as 455 vibrations a second.

I had the happy privilege of working with Professor Langley. I knew all the little flying machines with which he experimented. I saw the great model with which he had planned the first successful flight. The world said it was a failure and Langley, my good friend, died of a broken heart. Don't think that these engineers, these dreamers of great dreams that come true to benefit all mankind, have happy lives! The tragedy of Langley came to me a few years ago when I was sailing 2,000 feet above the sea in California in a flying machine.

There are on my list 180 names of men who have done something to make the world go round more smooothly on its axis, he said, and their unvarying characteristic is simplicity. The great man is the simple man who can get down and find out the reason of things.

But where will the credit for these achievements go finally? I say to the mothers, the sisters and the wives of the scientists. They bear the hard struggles; they know the pains of the achievement; they inspire. For five years Mrs. Brashear and I labored together in our little shop on the hillside in Pittsburgh making the first astronomical lens in America. I was working in the daytime, ten hours a day in the rolling mill. Nights my wife and I worked together. The critical moment of success had come. We went to our shop together that night so happy. Five years of work was to be finished. There was an accident. The lens was broken, the telescope ruined.

How I worked the next day I do not know. I was heartbroken, dulled, stupefied with grief. But up in the cottage on the hill a brave woman had gone smilingly to work. When I got home that night there was a fine supper; in the shop a new disc had been set up, the machines all made ready. And, inspired and cheered, we worked and in two months more the work of five years was regained.

Following the addresses a social hour was spent, when an elaborate buffet luncheon was served by the hosts of the evening, after which there was dancing.

WEDNESDAY AT NIAGARA FALLS

Special cars were ready at the Hotel Statler on Wednesday morning for the day's outing at Niagara Falls. One hundred and fifty joined in the trip, arriving at the Shredded Wheat Company's factory at Niagara Falls where the business session and the professional session which followed were held. Simultaneous with these was a conference of the representatives of local sections and the Local Sections Committee.

At the business session, the report was announced of the tellers on the amendment to C-45 of the Constitution. There were 1182 votes cast: 1135 for the amendment, 5 against, and 42 defective. The effect of this amendment is to add to the list of standing committees a new Committee on Standardization.

Announcement was made of proposed amendments to C-48 and C-54 of the Constitution. The first relates to a special nominating committee and specifies:

> C-48 Any group forming one per cent of the persons entitled to vote may constitute itself a Special Nominating Committee, with the same powers as the Annual Nominating Committee appointed by the President.

The second proposed amendment relates to the copyrighting of reports and papers and reads as follows:

> C-54 The Society shall claim the exclusive copyright to any reports of its duly appointed committees. The Council shall waive such copyright for specific reports. The Society shall copyright all papers read before the Society, printing thereon in each instance that the paper may be reprinted by anyone after the same has been read before the Society, provided that due credit be acknowledged to the Society and the author. The policy of the Society shall be to give the professional and scientific papers read before it the widest circulation possible, with the view of making the work of the Society known, encouraging engineering progress and extending the professional reputation of its members.

The Secretary presented that portion of the report of the Committee on Special Threads for Fixtures and Fittings covering rolled thread screw shells, together

with a letter from T. C. Martin, Secretary of the National Electric Light Association, which contained the approval of the Chairman of their Lamp Committee and Committee on Wiring of Existing Buildings, of the N. E. L. A. It was voted that the report be received and printed in the usual way.

The balance of the morning after the transactions of the Society's business was devoted to the discussion of professional papers.

A number of the visitors took advantage of the opportunity to inspect the Shredded Wheat Company's plant, and at one o'clock those who had been attending the meeting, and the ladies who had accompanied the party and who had spent the morning in the enjoyment of the attractions of Niagara Falls, gathered for luncheon at the International Hotel. After luncheon, the group was photographed and then the party was divided into sections for the gorge trip, and for inspecting the power plants of Niagara.

LECTURE BY DR. F. H. NEWELL

An entertaining lecture was given on Wednesday evening by Dr. F. H. Newell, of the University of Illinois and formerly Chief of the U. S. Reclamation Service. The subject was The Engineer as a Citizen, and beautifully colored lantern slides were used of striking views of the reclamation work. An abstract of the lecture is given elsewhere.

PROFESSIONAL SESSIONS

On Thursday morning there were two simultaneous sessions and a concluding session on Friday morning. Fourteen papers were presented in all, several of which were highly technical in character, and drew out a thoughtful and strong discussion. The sessions were well attended, particularly the one on Friday morning. On Thursday, although there were counter-attractions in the way of excursions and opportunities for automobile trips, a large audience was maintained at both of the sessions. A list of the papers follows, and abstracts will be published in later issues of The Journal:

A Study of an Axle Shaft for a Motor Truck, John Younger

A Comparison of the Properties of Nickel, Carbon and Manganese Steel Before and After Heat Treatment, Robert R. Abbott

The Use of Corrugated Furnaces for Vertical Fire-Tube Boilers, F. W. Dean

On Measuring Gas Weights, Thos. E. Butterfield

A Basis for Rational Design of Heat Transfer Apparatus, E. E. Wilson

Influence of Disk Friction on Turbine Pump Design, F. zur Nedden

The Surface Condenser, C. F. Braun

Some Mechanical Features of the Hydration of Portland Cement and the Making of Concrete as Revealed by Microscopic Study, Nathan C. Johnson

Design of Rectangular Concrete Beams, Howard Harding

Model Experiments and the Forms of Empirical Equations, Edgar Buckingham

The Effect of Relative Humidity on an Oak Tanned Leather Belt, W. W. Bird and F. W. Roys

On the Laws of Lubrication of Journal Bearings, M. D. Hersey

The Relation Between Production and Costs, H. L. Gantt

Laps and Lapping, W. A. Knight and A. A. Case

THURSDAY EVENING'S RECEPTION

The reception and dance on Thursday evening was one of the most delightful events which it has been the pleasure of the members to attend at any of the gatherings of the Society. Through the efforts of the local committee the arrangements had been carried to a high degree of perfection. The music was by Moll's orchestra of Rochester, N. Y., which is deservedly one of the popular orchestras of the state, and which contributed much to the pleasure of everyone who joined in the dancing. Late in the evening the party proceeded to the dining room of the Hotel Statler where a collation was served and a social hour was spent.

ENTERTAINMENT FOR GUESTS

The receptions on Tuesday and Thursday evenings have already been referred to in this account as events of much interest. Another pleasurable occasion was the opening of the Twentieth Century Club of Buffalo by its members for the entertainment of ladies and members in attendance at the convention. Tea was served there on Thursday afternoon and a large number accepted the hospitality of the club. Many of the prominent women of Buffalo were in attendance to receive the guests.

During Wednesday and Thursday, automobiles were placed at the disposal of the visitors for trips about the city or for the purpose of reaching manufacturing plants or points of interest. A special trip for the ladies was arranged on Thursday morning to view the interesting points of the city.

Still further, the local committee had thoughtfully made provision for any of the members who so desired to use the facilities of any of the clubs of Buffalo, special stamps being issued for this purpose

EXCURSIONS

Accounts of the many Buffalo manufacturing plants, which extended invitations to the Society to visit their works during the convention, have already been published in the last two numbers of The Journal. That the members and their friends were appreciative of these invitations is evidenced by the numerous visits which were made. Large parties went to the works of the Lackawanna Steel Company, the Snow Steam Pump Works, the Pierce-Arrow Motor Car Company, Larkin Company, and smaller groups to various other plants. A good many stayed over on Friday afternoon for the purpose of visiting plants which time had not permitted them to inspect on the previous days.

THE ENGINEER AS A CITIZEN

ABSTRACT OF AN ADDRESS BY F. H. NEWELL,

WEDNESDAY EVENING, JUNE 23

In his devotion to technical details does the engineer overlook some of his larger duties as a citizen? This is a question that we may well ask while in the midst of our professional discussions. It has already been ably brought out in the talks of last night by President Brashear and Mr. Baird, that the engineers are " dreamers whose dreams come true." They are men who study to control the forces of nature and who have brought about, especially during the last generation, most wonderful developments along mechanical lines, increasing the strength and efficiency of each worker by a hundred or a thousand fold.

While great results have thus been achieved in the handling of inert material, in the use of iron and steel, in the control of heat and electricity, yet it may well be asked whether there has been corresponding progress on the part of the engineer in the beneficial control of human forces and sentiments? It has been asserted, and quite generally accepted as true, that the typical engineer is a man who sits in his inner office, absorbed in abstruse calculations and wholly unaware of the great changes which are taking place along other lines of growth. It has been further urged that he is not doing his whole share as a man and a citizen, while performing a giant's task in his special line. While each of us must have our specialty, yet the engineers as a whole cannot afford to be so centered upon details as to lose out in broad human interests. If, as has been asserted, the engineer is not receiving such recognition from the public as will enable him to perform the largest public service, is this not due in part to his own neglect of some of these larger matters? This is a question which I wish to raise, not for discussion at this time, but rather for further personal consideration. I will ask each of you to reflect at leisure as to whether you as an individual are doing your full share to let the public know of the achievements of other engineers and of the engineering profession as a whole to aid the public.

It has well been said that the works of the engineer should speak for themselves, but many of the greatest works cannot speak for themselves; they are out of sight, hidden from view, existing as deep and difficult foundations for lofty superstructures, or as tunnels, waterworks and sewers, the essential mechanism for which is buried far from human sight. If the public who pays the bills is to appreciate fully these great achievements, the public must be told of them in language it can understand. The ordinary man cannot and does not read the technical descriptions of these great works. He is interested in them if the larger facts are presented to him in their true perspective and in a way that he can comprehend. He is satiated with startling, sensational stories, and turns with relief to simple, but definite descriptions of engineering works and of the difficulties which have been overcome. It requires, however, something of genius to state clearly and concisely the principal facts of engineering achievements without involving these in a mass of confusing details and technical language. A writer has said, " Any fool can write a book, but it takes a genius to write a paragraph." This applies with equal force to much of our technical literature. Any man of ordinary ability can write a technical paper which perhaps he and two or three other experts can understand, but it requires a man of somewhat unusual ability to state the same facts in a shorter but interesting manner. There is hardly a technical paper which has been delivered before the Society that does not have the elements of popular interest if the important points are brought out in their true relations to ordinary human affairs.

Assuming that there is some duty along this line which has not been fully performed by the engineers individually or collectively, is it possible for us to retify these omissions either by definite action by this and other national engineering organizations, or by co-operation among the local engineering societies? My personal belief is that the engineering profession as a whole is capable of being more immediately advanced in public esteem through strong, active, local societies than through any other one agency. These local societies to be effective, however, should be inclusive in the sense that they bring into their membership all engineers of good repute in the vicinity, and associate with them all men who are interested in engineering as a whole, and who are willing to show this interest by attending the meetings or by keeping up the annual dues. The strength of such a local society lies in its ability to diffuse information not only regarding local engineering problems, but also in bringing to the attention of its members and to the citizens of the vicinity the engineering achievements elsewhere, especially those which have a bearing upon the solution of local problems. From my experience in aiding in organizing and in conducting local societies, I cannot too strongly urge the importance of the profession as a whole of the proper stimulation of such organizations. Their best relation to the national societies is yet to be worked out, but it is a problem which undoubtedly will be solved in the near future.

Taking up a little more in detail the duties which may be and should be performed by the engineers acting in cooperation or through local and national societies, attention should be directed first to the necessity of a larger and better education of the public as to the fact, which all engineers recognize, of the superior opportunity and ability of the engineer to answer many of the vexatious questions of civic interest. There has been too general ignorance of the fact, for example, that most of the problems relating to public utilities should be solved on the basis of sound engineering. It should no longer be possible for the Governor of a large state to be unaware of the qualifications of engineers for public utility commissions and with well meaning ignorance pass over the consideration of the appointment of engineers on these commissions. The fact that a Mayor of one of the largest cities of the United States refused to appoint an engineer on a public health board because in his opinion the duties appertained to those of business men and physicians, reflects unfavorably upon the engineering profession of that city in not seeing to it that the Mayor was properly informed on the fact that most of the problems of sanitation are those purely of engineering. In other words, the ignorance of public officials and of the public in general on many of these matters, may be not so much the fault of the individuals and communities as it is of neglect on the part of the engineers as a whole to let it be known that many of these problems lie within the province of the engineer for solution.

Without going further into these details, I will, as before

stated, simply raise these points as questions for individual consideration, and take up a brief description of some of the larger pieces of engineering work of importance to all citizens which have been brought nearly to completion by the Reclamation Service of the United States. You as citizens and part owners of the great area of public lands are interested in this work; you are directly or indirectly furnishing the money and should enjoy some of the beneficial results. The work as a whole illustrates some of the "dreams which have come true," and may serve to give a little broader view of the practical applications of mechanical knowledge employed in developing the latest resources of the West. In any event, I should like to introduce you to some of the breezy western optimism and breadth of views which result from life upon the almost boundless arid lands of the west. The views which I am presenting can show only a few of the works for which over $80,000,000 of public funds have been spent, and which have rendered available for cultivation nearly 2,000,000 acres of fertile land. For this expenditure many large storage dams have been built, holding flood waters and furnishing a supply to many thousand miles of canals and distributing ditches. Connected with this work has been the construction and operation of electrical power plants, mills, steam and electric railroads, commissaries, hospitals, mines, and almost innumerable mechanical devices for the control and distribution of water to furnish opportunities for homes for many thousand families of the type which will form the backbone for a permanent and progressive citizenship, independent and self-supporting—the best and most effective of our people.

MEETING OF THE BOILER CODE COMMITTEE

An important meeting of the Boiler Code Committee was held on Wednesday and Thursday, June 23 and 24, at the headquarters of the Spring Meeting in Buffalo, at which several important actions were taken. Perhaps the most important was that relative to the use of the A.S.M.E. symbol as a boiler stamp. At a previous meeting, the question of authorization of its use in this manner had been referred to the Council, with the result that the Council referred the matter back to the Boiler Code Committee for recommendation and report as to the preferred usage. The result of careful discussion of the subject at this meeting was a resolution offered to the Council, as follows:

> It is the opinion of the Committee that the official symbol or stamp is to be used to indicate that The American Society of Mechanical Engineers' rules have been complied with in the construction of the boiler. The stamp shall be affixed by the manufacturer. Certification may be governed by law or contract.

The resolution was accepted by the Council, and it will be of interest to the boiler making industry to know that the A.S.M.E. stamp as prescribed in the Code will be open to general use for this purpose.

Another important problem that had arisen in connection with the Boiler Code was that of interpretation of the rules therein. In a number of cases questions have arisen since the Code was issued relative to application of particular rules in special cases of boiler construction, and as to the exact meaning of certain of the rules in which the application proves to be obscure. As the result of many requests for interpretation in such cases, a second resolution was offered to the Council by the Boiler Code Committee, as follows:

> Your Committee requests that it be empowered to make rulings where inquiries are made respecting constructions not covered by the Code, and to interpret any parts of the Code.

This resolution was also accepted by the Council, and the Committee devoted its entire second session to the consideration of these inquiries and proper replies to them. In all, ten cases were considered and interpretations formulated. It was arranged that each case ruled upon shall be given an index number, and the ruling thus made shall stand as a permanent interpretation of the particular portion of the Code involved.

Further arrangements for the interpretation work were made at this meeting in order that no obstacle be placed in the way of the application of the Code to the industry, by a provision for quarterly meetings of the Committee, or as much oftener as may be necessary, for consideration of such inquiries for rulings. The importance of this phase of the Committee's work was fully recognized, and it is hoped that by this plan the application of the Code to conditions in any community may be facilitated and its usefulness extended.

Recognition was given to the International Engineering Works, Framingham, Mass., for the copy of official tests on boiler joints which had been made at the Watertown arsenal for this Company on May 15, 1915. The receipt of this report of test data was acknowledged, and a resolution was offered that it be placed on file in the United Engineering Library in New York City.

Consideration was given to the matter of the index that has been prepared for the Boiler Code, and it has been ordered printed with slight revisions and a change of arrangement. The index will be arranged in two parts, one a complete alphabetical index of the entire work, and the other a divisional index divided into three parts, one corresponding to each of the three principal parts of the Code. It is intended that this index shall be incorporated in the next edition of the Code, which will, in all probability, be printed early in the Fall.

The matter of further work of the Boiler Code Committee was considered at this meeting, and the result was a third resolution offered to the Council as follows:

> Your Committee requests that it be empowered to take up the subject of (1) economizers; (2) pressure vessels; (3) rules for operation and care of steam boilers and pressure vessels; and (4) recommendations.

This request was also granted by the Council, and the Committee thereby authorized to proceed with this work as originally intended.

CONFERENCE OF LOCAL SECTION REPRESENTATIVES

The conference of local sections at the Spring Meeting reflected the wisdom of the Council in appointing the Committee on Local Sections last January. The personnel of this committee is: Elliott H. Whitlock, chairman, W. F. M. Goss, Louis C. Marburg, Walter Rautenstrauch, and D. Robert Yarnall; two of the committee are members of the Council, one the president of the Cleveland Engineering Society, and another past-president of the Philadelphia Engineers' Club, and they are, therefore, well-qualified to develop this important phase of the Society's activities.

There were present delegates from all parts of the country representing the following centers where sections are established.

Atlanta, FRANK H. NEELY
Buffalo, DAVID BELL, C. H. BIERBAUM, W. H. CARRIER, and JOHN YOUNGER
Chicago, P. A. POPPENHUSEN
Milwaukee, LOUIS E. STROTHMAN
Minnesota, MAX TOLTZ
New Haven, GEORGE S. BARNUM
New York, H. R. COBLEIGH
Philadelphia, D. R. YARNALL
St. Louis, E. R. FISH
San Francisco, C. F. BRAUN
Worcester, E. HOWARD REED and JAMES A. WHITE

The first session of the meeting, which continued through three sessions, took the form of a dinner on Tuesday evening with after-dinner speaking confined to the subject of Local Sections. The great interest which was manifested in the conference is evidenced by the fact that at the various sessions there were present, in addition to the regular delegates, Dr. John A. Brashear, President of the Society, James Hartness, Past-President, John R. Freeman, Past-President, H. G. Reist, Vice-President, Henry Hess, Vice-President, A. M. Greene, Jr., Manager, Calvin W. Rice, Secretary, and H. Wade Hibbard. In attendance also were William P. Caine, representing Birmingham, Ala., William T. Magruder, representing Columbus, Ohio, and H. H. Esselstyn representing Detroit, Mich., which centers now have the establishment of local sections under advisement, and Luther D. Burlingame representing Providence, R. I. The only sections which were not represented at the meeting were Boston, Cincinnati and Los Angeles.

The Committee on Local Sections had collected data from which the chairman had plotted curves showing the number of meetings held during the past year by the various sections, the cost per meeting, the attendance per meeting and the cost per member per meeting. These figures brought out many discrepancies and showed that the average cost of each meeting varied from $30.00 at San Francisco to $114 at New York. Other curves showed that the cost of meetings per member per year varied from 50 cents per member to over $2.50 per member.

Each representative present was given opportunity to put on record the ideas of his section and this information should prove of great assistance to the Committee on Local Sections in formulating plans which will, as nearly as possible, unify the procedure of all sections and also establish a basis for appropriating funds for carrying on their activities, which it will be endeavored to have commensurate to the requirements of the different sections and on as liberal a basis as the various activities in which the Society is engaged will permit.

Wide differences of opinion were expressed as to the relations which should exist between the Society and the sections and as to the scope of their activities. The delegates returned to their various sections with many new ideas which should prove a boon to the work, and the investigations of the committee will be continued through correspondence so that a satisfactory solution of the question will be found as promptly as possible.

INCREASE OF MEMBERSHIP

At the Spring Meeting the Chairmen of Sub-Committees on Increase of Membership met for the purpose of exchanging ideas, and planning ways and means of securing for the Society the support of the many leading engineers in various parts of the country who have not yet become affiliated with the Society.

The Chairman of the Committee, I. E. Moultrop, found it impossible to be present, but sent a letter addressed to those in attendance of which the following is an extract:

"I have one thought to suggest to our Committee. In almost every instance where a member of the Society has not enthusiastically responded to our request for help, he has emphasized his thoughts that people are prone to weigh the tangible returns they would receive from membership in our Society against the annual expense of that membership. This is a very practical viewpoint, but frankly, is a very short sighted and selfish one. If I were so situated that I received absolutely no tangible return for my membership in the Society, I should still feel that it was my duty to continue as a member; I should feel that I ought to do something for the mechanical engineer, something for the general good of the profession that furnishes a living to the mechanical engineers of this country. In the address given by L. B. Stillwell at the third Mid-Winter Convention of the Institute of Electrical Engineers, New York, February 17, 1915, he says in one place:

'The opinion is widely prevalent throughout the ranks of the profession that the true status of the engineer is not recognized by those about him; that the work which he has done and is doing in the world entitles him to a larger place in the public view than he now occupies and to a larger share in the administrative work of the nation, state, local community, and of our great railway and industrial corporations than he now enjoys.'

"Mr. Stillwell's statements, in my opinion, are absolutely true and the responsibility for the situation is with the mechanical engineers of this country. They do not take themselves seriously enough, and they are not a unit in trying to impress the world that the mechanical engineering profession is in importance second to none. English people are very frank in stating that the present European war is a war of engineers, and if this is so, mechanical engineering must play the principal role.

"I am not only willing but glad to make my small contribution towards the general benefit of the engineering profession, and I think every other engineer ought to feel he has a similar duty. I think we should make more of an effort to impress this viewpoint on the large number of engineers who are not but should be members of our Society."

The following were present at the two sessions of the Committee: F. H. Neely of Atlanta, W. H. Carrier of Buffalo, P. A. Poppenhusen of Chicago, H. H. Esselstyn, N. G. Reinicker and A. L. Burgan of the Michigan Committee, Max Toltz of St. Paul, J. A. Kinkead of New York, E. R. Fish of St. Louis, and C. F. Braun of San Francisco.

The members of the Committee were urged to impress those members of the Society with whom they come in contact that in no instance is an invitation to join ever extended by the Society or any of its officers as such. The work of the Committee on Increase of Membership is confined to urging the membership at large to see to it that every engineer of attainment is affiliated with the Society and giving through it his moral support to promoting the best interests of his profession.

Those associated in the work of the Committee on Increase of Membership and its Sub-Committees should always act as individuals when extending to their friends and associates an invitation to apply for membership.

Emphasis should also be made of the fact that the membership has greater opportunity now than ever before to make objection to candidates who should not be admitted. The method formerly used provided every voting member with a pamphlet containing a summary of the professional qualifications of those who had applied for membership during the previous six months.

The last issue of this pamphlet contained 208 pages of data covering 619 applicants. Inquiry proved that the great expense in publishing and distributing this information was not warranted because of the small percentage of the membership who took the time and trouble to peruse it.

In its stead was adopted a more simple but just as adequate system and at but a fraction of the cost. This consists of publishing the name, occupation, and address of the applicant listed under a heading for which his age and professional qualifications appear to fit him.

This method makes it possible for every member to examine the list every month. If any member, voting or otherwise, questions the eligibility of anyone posted, he may receive upon request a complete copy of the professional record of that applicant. Any applications for which information is requested, are held up until careful investigation is made and the member raising the question has had opportunity to give complete details, and these are either disproved or the application is indefinitely deferred. This gives the member an opportunity to secure information concerning those whom he questions without the trouble of looking through a lot of details regarding applicants he does not know.

The Membership Committee, made up of an entirely separate group of members than those working on the Increase of Membership Committees, uses the utmost care and gives most careful scrutiny to the records of the applicants, the remarks made by sponsors and any information which may be sent in by other members of the Society.

That the efforts of the Committee on Increase of Membership have borne fruit is evidenced by the following table:

RECORD OF APPLICATIONS RECEIVED MONTHLY FOR THE PAST EIGHT YEARS

(Committee on Increase of Membership Appointed in January 1912)

	1908	1909	1910	1911	1912	1913	1914	1915
January	28	29	35	44	44	140	92	49
February	21	39	40	54	81	240	110	123
March	51	39	38	31	110	49	323	167
April	41	37	28	21	49	52	83	68
May	28	36	28	22	34	47	69	66
June	33	15	30	27	63	47	52	156
July	20	21	19	34	68	54	131	....
August	21	22	15	33	156	98	61	....
September	17	26	28	37	74	188	68	....
October	49	29	30	33	36	64	63	....
November	26	32	27	22	42	58	50	....
December	35	29	34	49	53	84	53	....
Total	370	354	352	407	810	1121	1155	629

Owing to the general condition of business the activities of the Committee on Increase of Membership were reduced to the minimum last summer, and the result is apparent in the figures from August 1914 to January 1915. It will be noted that in the first six months of 1914 a total of 729 applications were received, whereas in the corresponding period this year 629 applications have been filed.

Many of the most prominent engineers now in the Society have joined since 1911, and in almost every instance their affiliation was the result of activity on the part of some member connected with the Committee on Increase of Membership. The high standard of the membership acquired during the past four years is shown by a perusal of the Year Book and a comparison of the members shown to have entered the Society since 1911 with those who entered prior to that time.

COUNCIL NOTES

A meeting of the Council was held in Buffalo, Thursday, June 24, 1915, at Society Headquarters, Hotel Statler.

The President announced the appointment of a committee consisting of Charles Whiting Baker and A. M. Greene, Jr., to represent this Society in conferences to be called by the American Society of Testing Materials.

Mr. Whitlock, chairman of the Committee on Sections reported that there was a great deal of interest shown in the conference of the representatives of the sections, which was then in progress. These representatives had come from all portions of the United States, including even San Francisco and Atlanta.

The Secretary reported the deaths of B. F. Isherwood, Honorary Member, John Birkinbine, G. T. Reiss, A. L. Bowman, John P. Zipf, and James T. Halsey.

Honorary Vice-Presidents which included H. R. Towne, W. M. McFarland, J. B. F. Herreshoff, Stevenson Taylor, had been appointed to represent the Society at the services to Mr. Isherwood; at the memorial services in honor of F. S. Pearson, J. W. Lieb, F. A. Halsey, H. G. Stott, F. A. Goetze were appointed as Honorary Vice-Presidents.

Election of applicants for membership was announced, on the ballots which closed May 29, and June 19th.

The resignation of C. W. Huntington was accepted.

Nominations for officers for the ensuing year were reported by the Nominating Committee, and appear elsewhere in the Journal.

The Council confirmed the appropriations of $100 approved by the Executive Committee for the work of the Committees on Student and Junior Prizes.

Approval was given to the appointment of E. A. Stillman on the Committee on Hydraulic Flanges.

Prof. Arthur M. Greene, Jr., one of the representatives of the Society on the joint Engineers' Committee with reference to the constitutional convention, reported the progress that had been made in recommending changes in the constitution, with respect to engineering matters.

The Committee on Sections in San Francisco, consisting of F. W. Gay, Chairman, F. H. Varney, Vice-Chairman, C. F. Braun, Secretary, H. L. Terwilliger, J. T. Whittlesey, likewise the Chicago Section Committee was approved, of H. M. Montgomery, Chairman, Joseph Harrington, Vice-Chairman, Robert E. Thayer, Secretary, Charles E. Wilson and H. T. Bentley.

New Orleans was chosen as the place of the Spring Meeting, 1916. The Society has never met in New Orleans, and has been in receipt of very cordial invitations for several years past, from the members there and from the Louisiana Engineering Society.

REPORT OF THE NOMINATING COMMITTEE

The Secretary announces the receipt of a report from the Nominating Committee in which the following names are offered as candidates for the offices indicated:

For President:

D. S. JACOBUS, New York

For Vice-Presidents:

WM. B. JACKSON, Chicago, Ill.
J. SELLERS BANCROFT, Philadelphia, Pa.
JULIAN KENNEDY, Pittsburgh, Pa.

For Managers:

JOHN H. BARR, New York
JOHN A. STEVENS, Lowell, Mass.
H. de B. PARSONS, New York

For Treasurer:

WM. H. WILEY

COMMITTEE ON PROTECTION OF INDUSTRIAL WORKERS

The Committee on Meetings has recently established a Sub-committee on Protection of Industrial Workers. The members of this new committee are: JOHN H. BARR, *Chairman;* MELVILLE W. MIX; JOHN PRICE JACKSON; WILLIAM A. VIALL; JOHN W. UPP.

This committee desires to avoid all unnecessary duplication of work or conflict with the activities of other organizations, but is anxious to perform its part in bringing about the standardization of effective and practical protective devices and methods.

In order to define properly its scope and determine its limits of activity it solicits information as to what has been done and is being done through other agencies. These agencies include state bureaus, insurance interests, organized societies or their committees, departments of industrial concerns and individuals. Suggestions as to sources of such information, especially reports of committees and codes for safeguarding industrial risks, are solicited. The new committee of the A.S.M.E. asks the assistance of those already engaged in the safety movement, and desires to reciprocate by coöperating with others interested in establishing a more systematic practice in the reduction of industrial accidents.

It is the intention of the committee not to hastily recommend standards; any action in that direction will only follow mature consideration of all the pertinent evidence available. An effort will be made to review the work of other agencies and to secure the advice and opinions of those who can speak with authority before attempting any specific recommendations.

The field which may be covered is a large one and the committee will probably find it desirable to restrict itself to the consideration of certain classes of risks at the beginning of its work, extending to other lines later, as conditions and development may warrant.

The first work will be a survey and digest of what has been done, having particular regard to legal codes which have been adopted in various States, regulations and requirements of insurance organizations, and codes which have been adopted by other associations.

It is obvious that such safeguards as should be applied to machinery can best be supplied with the machines by the maker. This procedure will result in guards better in design and lower in cost than if made by hand in the works of the purchaser. No doubt the purchaser would give preference, other things being at all equal, to machines provided by the maker with well designed protective features. The manufacturer will appreciate the value of such features as selling points, especially after these get some vogue.

The great obstacle to the adoption of this practice of "built in" safeguards is the diversity of requirements and conflicting regulations in force in different sections of the territory over which any given product is distributed.

If The American Society of Mechanical Engineers, coöperating with other agencies, can effect an approach to uniform requirements in this matter, it will materially contribute to the reduction of accidents, and will vastly reduce the annoyances incidental to complying with legal and insurance requirements.

To expedite an approach to this desirable estate is the first aim of the Committee on Protection of Industrial Workers.

INTERNATIONAL JURY OF AWARDS

Panama-Pacific International Exposition

On this page is published a photograph of the four group Juries of Awards of the Panama-Pacific International Exposition having to do with machinery exhibits. The names of the gentlemen seated, reading from left to right, are: Prof. H. Wade Hibbard, Mem. Am. Soc. M. E.; Prof. Charles E. Lucke, Mem. Am. Soc. M. E.: Prof. John T. Faig, Mem. Am. Soc. M. E.; J. C. Mengel; George W. Dickie, Vice-President, Am. Soc. M. E.; Lieut. G. W. Danforth, Chief of the Dept. of Machinery; W. H. Onken, Jr.; Prof. C. M. Jansky; Geo. M. Brill, Mem. and Past Vice-President, Am. Soc. M. E.; Emil Fischer and Calvin W. Rice, Secretary of the Am. Soc. M. E. Those standing are, from left to right: Captain B. C. Bryan, U. S. N.; Fred R. Low, Mem. Am. Soc. M. E.; John Hunter, Manager Am. Soc. M. E.; Captain C. A. McAllister; F. J. Frank; D. S. Watkins; W. H. Crosby; Cecil P. Poole, Mem. Am. Soc. M. E.; Carl Hering; H. W. Bringhurst; Thomas Norriss; Prof. Wm. H. Kavanaugh, Mem. Am. Soc. M. E.; Jesse M. Smith, Mem. and Past-President, Am. Soc. M. E., and N. A. Bowers.

The exhibits in the machinery buildings and those in the exposition generally which had to do with mechanical and electrical devices were divided nearly equally among four group juries. These juries were smaller than in previous expositions for the reason that it has been found that a small group is more efficient than a large one.

Members of the Four Group Juries of Panama-Pacific International Exposition

The chairmen of the respective groups were: Mr. Dickie, Tools for Shaping Wood and Metals; Mr. Brill, General Machinery and Accessories; Mr. Low, Steam, Gas, Hydraulic and Other Motors; and Mr. Onken, Electrical Machinery. These gentlemen, together with the Chief of Exhibits, Mr. Danforth, became members of the Grand Jury which is still in session.

There were over 600 separate exhibits, about 150 to each group jury, and, in turn, each of the exhibits contained one or more items for which the exhibitor wished separate consideration.

The work of the juries consisted in passing upon each individual item, assigning a mark on a scale of 100, to a definite schedule representing the features which one should take into account in judging the exhibit, such as its usefulness, attractiveness, instructiveness, length of time the firm making it had been in business, whether or not the firm had received previous

awards for the same lines of manufacture, etc. The sum of the individual marks which each member of the group jury secured was reported to the secretary of his group and the average taken. This indicated whether there should be given no award, honorable mention, bronze medal, silver medal, gold medal or medal of honor, and the vote was taken by the entire group confirming the award.

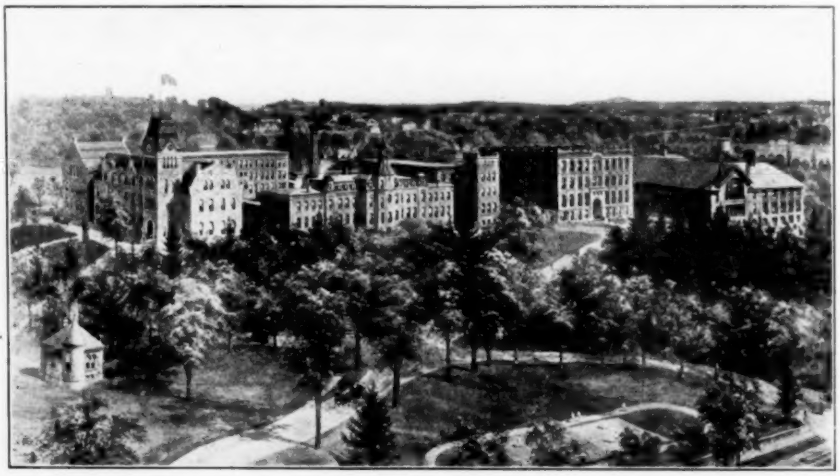
The care and unanimity of judgment of the individual members of the jury was indicated by the fact that the scheme of marking was so well thought out, and methods of arriving at judgments so definite, that the percentage variation from the average was usually very slight. Any person's individual judgment after the awards had been made by the group jury was in turn recommended to the superior jury for its review.

ENDORSEMENT OF THE BOILER CODE

Full endorsement of the Boiler Code as a set of rules for stationary boiler construction was the result of a resolution adopted by the Master Boiler Makers' Association at its ninth annual convention held recently at Chicago. The Executive Committee of the Association, after investigation, made the recommendation that the Association should adopt the A. S. M. E. Boiler Code, and this recommendation was favorably voted upon by the Association. The opinion was expressed that the Boiler Code is the best set of boiler rules that has ever been published and it was hoped that it would become a standard throughout the entire country.

Also advices have just been received that the A.S.M.E. Boiler Code has been adopted by the Industrial Board of the State of Pennsylvania and by the Board of Boiler Rules of the City of Detroit as their standards of boiler construction in their respective districts. It has also been reported that the use of the A.S.M.E. Boiler Code is being strongly agitated in the State of California, as well as in a number of other States, and it is said to be more than likely that it will be the standard of boiler construction in a large proportion of the States of the Union before the end of the year.

WORCESTER POLYTECHNIC INSTITUTE



Worcester Polytechnic Institute

The fiftieth anniversary of the founding of the Worcester Polytechnic Institute was celebrated on June 9. Delegates from nearly ninety colleges, universities and technical schools and from eight engineering societies were present. The Society was represented by Dr. John A. Brashear, President, and Calvin W. Rice, Secretary. Among the speakers were David I. Walsh, Governor of Massachusetts; A. Lawrence Lowell, L.L.D., president of Harvard University, and George I. Alden, of the board of trustees of the Institute and member Am. Soc. M. E.

Ira N. Hollis, president of the Institute, in his introductory address, expressed his regret that important duties elsewhere prevented President Wilson and Major-General Goethals from attending the function. He traced the connection between the hard experience of the men who had, on both sides, gone through the four years of the Civil War, and the subsequent rapid growth of the American industries led, to a large extent, by the men who, in the words of the speaker, have "brought away from four years of hard fighting, clean hearts." The problem of the day in this country is the necessity of greater care of our natural resources and less waste of available material. Recent laws have not accomplished as much by direct enforcement as they have by indirection, by public discussion, or by the formation of public opinion. In this aspect of American life the universities and colleges have a more important function than the legislatures.

President Lowell compared the life led by the Romans with that of the present generation. The conditions of life were profoundly different from what they are today, and in many cases the gulf in moral conceptions was nearly as deep: in Athens, Plato and Socrates said that slavery was an absolute necessity, not only for human prosperity but still more for human progress. It was not so much the change in morals, as the progress in engineering, control of the forces of nature, that brought about the establishment of the new, and better order of things, but, President Lowell added with emphasis, in controlling the forces of nature, one should know something of the com-

munity in which one lives, and the effects which a certain application of these forces will produce on the life of the community.

The same strain, the imperious need of a connection between the work of the engineer as such as a member of the community of which he is a part, was still more forcibly impressed in the address of Governor Walsh of Massachusetts. An institution like the Worcester Polytechnic Institute, he said, is specially valuable to the commonwealth in that it equips men to grapple with the problems of government, and to "preserve the blessings and the liberties the people enjoy unsullied and unstained," a significant statement when addressed to a purely technical institution.

The address of George I. Alden was given before a meeting of the local section of The American Society of Mechanical Engineers, held in the afternoon and simultaneous with the celebration exercises. His address appears elsewhere in this issue.

CONVENTION OF THE NATIONAL ASSOCIATION OF CORPORATION SCHOOLS

Of general interest in connection with the meeting on June 8 of the Worcester local section of the Society, and of the celebration of the fiftieth anniversary of the foundation of Worcester Polytechnic Institute, referred to elsewhere in this issue, is the third annual convention of the National Association of Corporation Schools that was held at Worcester at that time. The meetings which extended over four days, June 8-11, were presided over by Charles P. Steinmetz, president of the Association, Mem. Am. Soc. M.E., and they were devoted to discussions of the many important problems entering into industrial education, such as trade apprenticeship, special apprenticeship schools, vocational guidance, office work schools, etc. More than 150 representatives of many of the largest industrial corporations in the country were present.

The address of welcome was made by George I. Alden, president of the Norton Companies, who gave the reasons why such large corporations may conduct schools in their own works and at their own expense. He pointed out the great opportunity offered by the Association for corporations to come into closer relations of personal contact, knowledge, and interest with their employees, to offer them vocational guidance, to increase the wages of employees by increasing their specific knowledge, and consequently their value to the corporation, and thus secure a unity, permanence, and efficiency throughout the whole organization, which will be of mutual benefit to all.

In connection with the meetings of the Association which were held in Higgins Hall of the Worcester Boys' Trade School, the memory of Milton P. Higgins, who was a member of the Society, was honored as founder of the school. Mr. Higgins, who was referred to as the father of trade schools, believed that the productive shop was an essential factor in successful trade training, and his early work in connection with the Polytechnic Institute and later—in founding the Trade School, which was the culmination of his twenty-eight years of business life at the Polytechnic Institute, proved that his belief was well founded. His memory was honored by the presentation of two fine bronze tablets which have been placed by his family at either side of the entrance of the Trade School for Boys building.

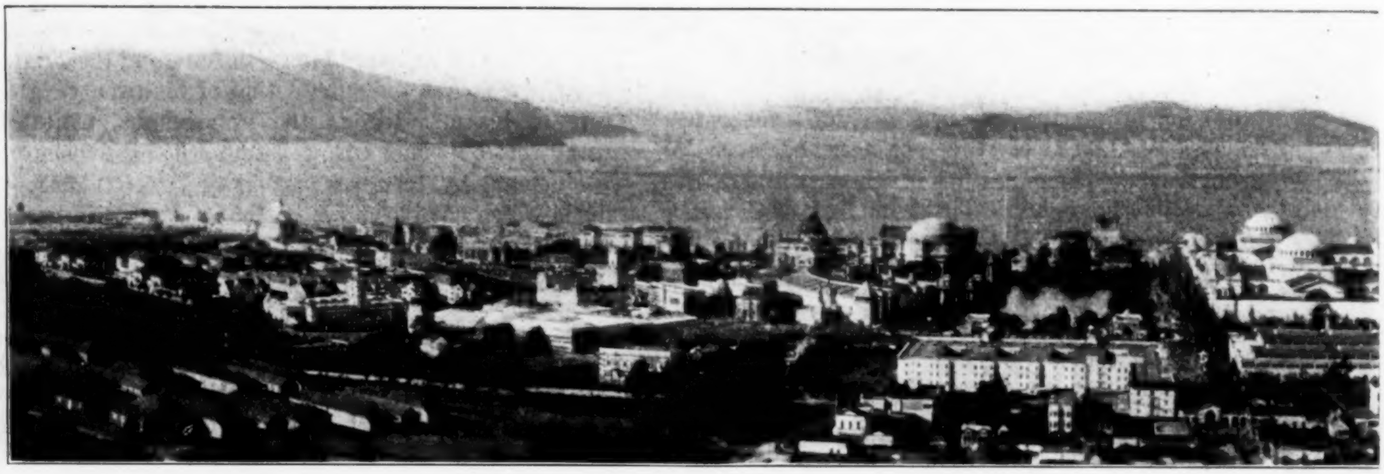
JOHNS HOPKINS UNIVERSITY

On May 20, Dr. Frank J. Goodnow was installed as the third president of Johns Hopkins University at Baltimore, Md. The inauguration was preceded by a procession of the delegates consisting of presidents of more than fifty American and Canadian colleges and universities, faculties, trustees, alumni and graduate and medical students. The Society was represented by Prof. Carl C. Thomas, professor of mechanical engineering at the University. Dr. Goodnow in accepting the responsibilities of the office, made an address on Modern Educational Ideals. He said in part:

The complaint is often made that modern education is too practical in its aims, and as a consequence, the coming generation will lose much of the beauty and richness of life which those of the present owe to their pursuit in past years of what are usually called cultural as opposed to vocational studies. An examination of the history of universities would seem to show that almost everywhere and at almost every period the primary purpose of those seeking an education has been in very large measure a distinctly practical one. This purpose has been to acquire proficiency in the profession which they intended to follow. Even in the earliest time, tendencies were toward the practical side, and gradually subjects crept into the universities which were once considered in the nature of trades, but which were later looked upon as learned professions. The first of the new professions to be recognized by the university was medicine. Just as the development of an approximately scientific medicine resulted in transforming medicine from a trade into a learned profession, so the development of the engineering sciences has made the engineer out of the artisan, the architect out of the builder, and the scientific chemist out of the alchemist. At the present time, furthermore, new sciences and professions are in the making, such as the scientific agriculturist, the scientific forester, the naval architect, and the efficiency engineer.

It may be truthfully said, however, that educational ideals while perhaps more practical than formerly, are really to be distinguished from former ideals by reason of the fact that they are broader and more comprehensive. We no longer consider education as purely vocational or purely cultural. We no longer confine our study to theology and philosophy or to literature and mathematics. The functions of modern education are manifold.

They include the disciplinary training of the young along general lines, the transmission of that particular knowledge of the past which will do most to develop persons of culture, the applications of scientific methods to the conduct of the



PANORAMIC VIEW OF THE

ordinary affairs of life, the increase of our knowledge through research and investigation and the rendering of public service. None of those ideals is to be despised as unworthy of pursuit by men of learning. None perhaps may be selected as more worthy of pursuit than the rest.

On the following day, Dr. Henry C. Adams, professor of history of the University of Michigan and the first graduate of Johns Hopkins University, gave an address at the dedication of Gilman Hall. It sounded very forcibly the call to the study of those things contributing to the larger life of mankind without reference to the utilitarian objects of study, and was a plea for the things of the spirit.

Following Dr. Adams, and as the final feature of the program, General Goethals made a splendid address at the dedication of the Engineering buildings. After having pointed out the wonderful development of the creative arts in the last century, the speaker defined the relation between material progress and the moral progress of mankind. He said further:

In man much of the brute still remains, but, although no marked progress can be observed in the subjugation or eradication of human passions, the engineer has shown advancement in his cult, the direction of the great sources of power in nature to the use and convenience of man. The present war may be expected to be followed by an era of great industrial advance. Notwithstanding its horrors, war assists progress, as new industries are developed, and inventive genius is aroused and stimulated.

The work of the engineer is gradually tending to bring him into closer contact with other spheres of activity: with the physician in the preservation of public health; the lawyer in the drafting of contracts, enforcing and perhaps contesting them; perhaps even with the clergy in the handling of motley crowds in construction camps.

In the United States, it was the army that supplied the first engineers. West Point was the first, and for some time the only technical school in the country, and its graduates ranked high among the engineers of the United States. Later, when technical education was undertaken by the colleges and universities, graduates of the Military Academy were found among instructors and professors. Furthermore, it was the army which started the great work which subsequently developed into what is now known as the U. S. Geological Survey and the Coast and Geodetic Survey.

The speaker proceeded then to give a brief but highly interesting account of the creation of the department of engineering at the Johns Hopkins University, and made an eloquent defense of the principles laid at the foundation of its program. After all, in the words of Maj. Gen. Goethals, it is not the amount of technical information that is of importance. What is needed is so to train the mind that it can grapple with reasonable hope of successful issue the various problems that will arise in after life; and this is accomplished best by a thorough grounding in and mastery of the theory of the fundamentals.

THE GETTING-TOGETHER OF THE ENGINEERING PROFESSION AT SAN FRANCISCO

Traveling by the Engineers' Special to the International Engineering Congress at San Francisco will afford a unique opportunity for engineers and their friends to meet, on one train, the officers and members of the five national engineering societies under whose auspices the Congress is being held.

For a number of years, there has been developing a spirit of coöperation among the national engineering societies, and it is believed that the Congress will serve to unite further not only the engineering societies of America but also those of the entire world in one common effort.

The details of the excursion to San Francisco are briefly as follows:

Round trip ticket, via the Engineers' Special and returning by any route, can be purchased for $98.80. Pullman service and meals are of course extra.

The train leaves New York City at 7:45 p. m. on Thursday, September 9, and arrives in San Francisco at 9 o'clock on the evening of Wednesday, September 15.

The outgoing trip will allow stop-overs at Niagara Falls, Colorado Springs and the Grand Canyon.

Each of the national engineering societies will hold separate professional meetings on Thursday, Septem-

Panama-Pacific International Exposition

ber 16 and Friday, September 17. On Saturday and Sunday, September 18 and 19, excursions to points of engineering interest will be organized. These excursions include visits to the Potrero Gas Works, the largest gas station on the Pacific Coast, the San Francisco High Pressure Fire System, the Great Western Power Company's Hydroelectric Development, the Spaulding-Drum Development of the Pacific Gas and Electric Company and the Coalinga Oil Fields. During the following week, beginning September 20, the sessions of the Congress will be held jointly.

Col. G. W. Goethals will act as Honorary President of the Congress and is expected to preside in person over its general sessions. Prof. W. F. Durand is chairman and W. A. Cattell, secretary.

The papers presented will cover the general field of engineering and are intended to treat the various topics in a broad and comprehensive manner, with special reference to the important lines of progress during the past decade, the present most approved practices and the lines of present and future development. Furthermore, each will be accompanied by a bibliography of its subject.

The Congress has been handled with special wisdom on the part of a very loyal committee of which Prof. W. F. Durand is chairman, and by A. M. Hunt, chairman of the meetings committee. These men have given several years of unselfish devotion to the work, without remuneration of any kind. Notwithstanding this, the cost of literature, maintenance of headquarters, printing and publication of papers will be considerable and the Engineering Societies have undertaken to underwrite these expenses, but it is earnestly hoped that the members at large will support the Congress by their coöperation. The fee for membership in the Congress is only five dollars, but if a sufficient number of members enroll, the entire expense will be paid without calling upon the parent societies.

The Congress is a celebration by the United States of the greatest engineering achievement ever undertaken in the history of the world. It is fitting, therefore, that every engineer should be officially represented in its membership.

The following is a partial list of those who have signified their intention of attending the Congress and of journeying by the Engineers' Special. In this partial list only members of this Society are included. A total of 145 are now scheduled for the official train from New York and 21 for the train from New Orleans.

Nicholas S. Hill
Edwin B. Katte
Bradley Stoughton
Leonard Metcalf
Wm. H. Wiley and Mrs. Wiley
John H. Bernhard and Mrs. M. B. Bernhard-Nable
G. R. Tuska and Mrs. Tuska
W. L. Saunders
L. K. Comstock and party
James Hartness and Mrs. Hartness
R. J. Hill and Mrs. Hill
G. W. Fuller and Mrs. Fuller
Calvin W. Rice
Alex. C. Humphreys, Mrs. Humphreys and party
Ira H. Woolson and Mrs. Woolson
Charles A. Mead
A. Stucki, Mrs. Stucki and party
Ferdinand L. Schmidt and Mrs. Schmidt
A. H. Goldingham and Mrs. Goldingham
R. M. Clayton and party
Paul C. Philipp
Laurence C. Bowes
Reid Jones
Paul H. Grimm
W. J. A. London
H. J. Freyn and Mrs. Freyn
R. V. Norris
Robert B. Wolf and party
James M. Dodge, Mrs. Dodge and party
W. R. Warner, Mrs. Warner and party
Carl F. Dietz and Mrs. Dietz
P. M. Lincoln, Mrs. Lincoln and party
Henry G. Reist and Mrs. Reist
Robert W. Hunt
Frank B. Gilbreth and Mrs. Gilbreth

The headquarters of the Society will be at the Hotel Clift. The local arrangements will be in charge of a Committee on Local Affairs. A general program of the Congress and of the excursions will be mailed to members of the Society on request.

APPLICATIONS FOR MEMBERSHIP

TO BE VOTED FOR ON AUGUST 10, 1915

MEMBERS are requested to scrutinize with the utmost care the following list of candidates who have filed applications for membership in the Society. These are sub-divided according to the grades for which their age would qualify them and not with regard to professional qualifications, i.e., the age of those under the first heading would place them under either Member, Associate or Associate-Member, those in the next class under Associate-Member or Junior, while those in the third class are qualified for Junior grade only. Applications for change of grading are also posted.

The Membership Committee, and in turn the Council, urge the members to assume their share of the responsibility of receiving these candidates into the Membership by advising the Secretary promptly of any one whose eligibility for membership is in any way questioned. All correspondence in regard to such matters is strictly confidential and is solely for the good of the Society, which it is the duty of every member to promote. These candidates will be balloted upon by the Council unless objection is received before August 10, 1915.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

ADAMS, JAMES F., Supt. and Vice-Pres., The Canister Co., Phillipsburg, N. J.

ALQUIST, KARL, Engr., General Elec. Co., Schenectady, N. Y.

APPLER, A. BENJAMIN, Mech. Engr., The Delaware & Hudson Co., Watervliet, N. Y.

AUTEN, JAMES E., Asst. Supt. Bldgs. and Equipment, Cadillac Motor Car Co., Detroit, Mich.

BAREUTHER, ADOLPH A., Insptr., The Panama Canal, Washton, D. C.

BERTHOLD, FRANK C., Mech. Foreman, Illinois Steel Co., Gary, Ind.

BÖSCH, FREDERICK W., Designing and Cons. Engr., Murray Iron Works, Burlington, Ia.

BOYNTON, JOHN E., Ch. Engr., American Brick Co., Lincoln, Ill.

BROOKS, PERCY C., Vice-Pres., Canadian Fairbanks Morse Co., Ltd., Toronto, Ont., Can.

BROWN, JOHN W., JR., Cons. Engr., Baltimore, Md.

CHAMPION, DAVID J., Pres., Champion Rivet Co., Cleveland, Ohio

COHEN, ABRAHAM S., Mech. Engr., with C. L. Howes, M.E., Boston, Mass.

COKER, JAMES L., JR., Vice-Pres., Carolina Fiber Co., Hartsville, S. C.

COLLISTER, GEORGE F., Mgr., Crucible and Alloy Steel Sales, The Betz Pierce Co., Cleveland, Ohio

CONKLIN, HARRY R., Mining and Electrical Engr., Joplin, Mo.

CONNELLY, LAURENCE E., Vice-Pres., The D. Connelly Boiler Co., Cleveland, Ohio

CONNELLY, WILLIAM C., Pres., The D. Connelly Boiler Co., Cleveland, Ohio

COVELL, GRANT A., Dean of Sch. of Engrg. and Mech. Arts, Oregon Agri. College, Corvallis, Ore.

CUNNINGHAM, CHRISTOPHER, Pres., The Christopher Cunningham Co., Brooklyn, N. Y.

DYER, ORVILLE K., Asst. Sales Mgr., Buffalo Forge Co., Buffalo, N. Y.

ELLIOTT, WILLIAM S., Pres., Elliott Co., and Pres., Liberty Mfg. Co., Pittsburgh, Pa.

FOGARTY, MICHAEL, Boiler Mfr., Michael Fogarty Inc., New York

FREDETTE, JOHN, Supt. Tools and Equipment, The Westinghouse Mch. Co., East Pittsburgh, Pa.

FRITTS, CHARLES E., Elec. Engr., Metropolitan St. Rwy. Co., Kansas City, Mo.

FULLER, CHARLES E., Supt. Motive Pwr. and Mchy., Union Pacific R.R. Co., Omaha, Nebr.

GAGE, VICTOR R., Asst. Prof. Exper. Engrg., Cornell University, Ithaca, N. Y.

GEORG, THEODORE, Ch. Draftsman, Alberger Pump & Condenser Co., Newburgh, N. Y.

GORTON, CHARLES E., Gorton & Lidgerwood Co., New York

GRACE, JOHN F., Designing Engr., Henry R. Worthington, N. J.

GUNBY, FRANK McC., Specl. Asst., Charles T. Main, Engr., Boston, Mass.

HANSEN, JENS H., Mech. Engr., The Pelton Water Wheel Co., San Francisco, Cal.

HENDERSON, ERNEST G., Vice-Pres. and Mgr., The Canadian Salt Co. Ltd., Windsor, Ont., Can.

HOLT, PLINY E., Vice-Pres. and Genl. Mgr., The Holt Mfg. Co., Stockton, Cal.

HOPKINS, LLOYD C., Engr. and Designer, The Smith Gas Pwr. Co., Lexington, Ohio

HORSMAN, HERBERT W., Head of Planning and Rate Fixing Dept., Associated Equipment Co., Ltd., London, Eng.

HUBBELL, LYMAN P., Pres., Fillmore Ave. Fdy. & Iron Wks. Inc., Buffalo, N. Y.

HUNTER, SAMUEL R., Genl. Supt., Rawleigh-Schryer Co., Freeport, Ill.

JOHNSON, FRANK E., Supt., The Kelly & Jones Co., Greensburg, Pa.

JONES, PHILIP, Cons. Engr., Pinal Dome Oil & Refining Cos., Santa Maria, Cal.

KEANE, FRANK, Production Mgr. and Engr., Fritz Carburetor Co., Norristown, Pa.

KETTERING, CHARLES F., Vice-Pres. and Genl. Mgr., The Dayton Engrg. Lab. Co., Dayton, Ohio

KINDLUND, MARTIN G., Marine Architect and Cons. Engr., New York

KNAPP, EDWIN R., Prof. of Descrip. Geometry and Mech. Drawing, Stevens Inst. of Tech., Hoboken, N. J.

LANDER, ROSWELL S., Assoc. Engr., The Soper Engrg. Co., Chattanooga, Tenn.

LANE, FREDERICK L., Mech. Supt. and Engr., Haines, Jones & Cadbury Co., Philadelphia, Pa.

LAWSON, JAMES T., Ch. Operator, Public Service Elec. Co., Newark, N. J.

LEONI, ALFONSO M., Ch. Engr., A. M. Leoni Mfg. Co., Inc., Philadelphia, Pa.

LIEBERMANN, PAUL B., Engr. of Tests, Hyatt Roller Bearing Co., Newark, N. J.

LONGINO, JAMES L., Secy. and Engr., Arkansas Lt. & Pwr. Co., Arkadelphia, Ark.

LUCK, GEORGE A., Deputy Chief, Mass. Boiler Insp. Dept., and Chairman Board of Boiler Rules, Boston, Mass.

LUCKE, HERBERT R., Mgr., De La Vergne Engine Co., Houston, Tex.

MACDONALD, JOHN W. F., Ch. Draftsman, Internatl. Engrg. Wks., Framingham, Mass.

MACY, NELSON, Pres., Corlies, Macy & Co., New York

MALI, FRANKLIN F., Mech. Engr., National Metal Molding Co., Ambridge, Pa.

MARBLE, EDWIN H., Pres., Curtis & Marble Mch. Co., Worcester, Mass.

MICKLE, ROBERT R., Pres., Mickle-Milnor Engrg. Co., Philadelphia, Pa.

MILNOR, THOMAS W., with Kline Hardware Co., Inc., Allentown, Pa.

MOORE, M. F., Asst. to Pres., Kewanee Boiler Co., Kewanee, Ill.

NEVILLE, WILLIAM J., with Chapman Valve Mfg. Co., Indian Orchard, Mass.

PARKE, FREDERIC H., Res. Engr., S. E. Dist., Westinghouse Air Brake Co., Pittsburgh, Pa.

PHELPS, PAUL, Genl. Mgr., The Challoner Co., Oshkosh, Wis.

PRATT, AUGUSTE G., Asst. to Pres., The Babcock & Wilcox Co., New York

RADFORD, GEORGE S., Production Engr., Remington Arms & Ammunition Co., Bridgeport, Conn.

ROBBINS, HARRIS A., Supt. Pwr., Brooklyn Rapid Transit System, Brooklyn, N. Y.

ROHRBACHER, WILLIAM, Boiler Insptr., Hartford Steam Boiler Inspt. & Ins. Co., Erie, Pa.

SACHS, DANIEL M., Vice-Pres. and Genl. Mgr., Northern Pipe Line Co., Oil City, Pa.

SACKETT, ROBERT L., Dean of Engrg., Penn State College, State College, Pa.

SAUERHERING, RICHARD P., Mech. Engr., Motor Dept., General Elec. Co., Pittsfield, Mass.

SEDGWICK, HARRY A., Asst. Supt., The Cutler-Hammer Mfg. Co., Milwaukee, Wis.

SIGNAROWITZ, FERDINAND J., Designing Engr., Cameron Steam Pump Wks., Phillipsburg, N. J.

SKINNER, JAMES D., formerly in charge of Operating and Engrg. Depts., Northern Coal & Coke Co., Denver, Colo.

SPICER, CHARLES W., Master Mech., Fernwood Lumber Co., Fernwood, Miss.

STEM, FRANK B., Mech. Engr., Day & Zimmermann, Philadelphia, Pa.

STERLING, GEORGE R., Insptr., Hartford Steam Boiler Insp. & Ins. Co., Jersey City, N. J.

SWIFT, JOHN B., JR., Dist. Sales Mgr., American Rotary Valve Co., Chicago, Ill.

TAYLOR, FRANK W., Charge of Steam Turbine Erection, General Elec. Co.; Schenectady, N. Y.

THOMSON, P. FRESCOLN, Mgr., Thomson Tool & Supply Co., Indianapolis, Ind.

TURNER, RALPH E., Assoc. Editor. Practical Engineer, Chicago, Ill.

WEED, MARTIN B., Ch. Mech. Engr., Rock Island Oil & Mining Co., Dallas, Wyo.

WELD, LYDIA G. (Miss), in charge of Tracing Dept., Newport News Shipbuilding & Dry Dock Co., Newport News, Va.

WESTERVELT, WILLIAM I., Major Ord. Dept., Supt. Watervliet Arsenal Shops, Watervliet, N. Y.

WESTON, BURT H., Instr. in Mech. Drawing and Mch. Design, The David Ranken Jr. Sch. of Mech. Trades, St. Louis, Mo.

WEYKER, WILLIAM J., Asst. to Ch. Engr., Commonwealth Edison Co., Fisk St. & Quarry St. Stas., Chicago, Ill.

WHELAN, WILLIAM R. F., Ch. Engr., Hudson River Mills, Internatl. Paper Co., Palmer, N. Y.

WIKSTROM, MALCOLM U., Genl. Supt., Pittsburgh Steel Products Co., Monessen, Pa.

WILLIAMS, WILLIAM H., Draftsman, Pittsburgh Seamless Tube Co., Beaver Falls, Pa.

WILSON, HENRY C., Cons. Engr., Tech. Dir., Ord. Dept., Westinghouse Elec. & Mfg. Co., New York

WOOD, JOHN T., Mech. Supt., Franklin Process Co., Providence, R. I.

WOOD, ROBERT, Cons. Engr., Nathan Mfg. Co., New York

WOODBURY, JOSEPH G., Dept. Supt., Remington Arms & Ammunition Co., Bridgeport, Conn.

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

ABELL, ASHEL C., Instr. in Mech. Engrg., Washington State College, Pullman, Wash.

BARTON, RAYMOND L., Draftsman and Checker, American Car & Fdy. Co., St. Charles, Mo.

BETTIS, ALEXANDER E., Mech. Engr., Kansas City Elec. Lt. Co., Kansas City, Mo.

BLACK, WILLIAM, Asst. Prof. of Steam & Gas Engrg., Univ. of Wis., Madison, Wis.

BUENSOD, ALFRED C., Mech. Engr., Internatl. Cigar Mchy. Co., Brooklyn, N. Y.

CARY, JAMES W., with Puget Sound Traction Lt. & Pwr. Co., Everett, Wash.

COLE, HAROLD R., Ch. Draftsman, A. Schrader's Son, Inc., Brooklyn, N. Y.

CREWSON, G. G., Mech. Engr., The Roessler & Hasslacher Chemical Co., Perth Amboy, N. J.

DANIELS, ARA M., Asst. Mech. Engr., Off. of Pub. Rds. and Rural Engrg., U. S. Dept. of Agri., Washington, D. C.

DAVIES, THOMAS R., Ch. Constr. Engr., Nitrate Agencies Ltd., Iquique, Chile, S. A.

DICKEY, ARTHUR J., Genl. Mgr., C. A. Dunham Co. Ltd., Toronto, Can.

DOYLE, MARTIN A., 2nd Lieut. of Engrs., U. S. Coast Guard Cutter "Mohawk," Sta. N., New York

GOBIN, ANDRE F., Mech. Engr., Ingram-Hatch Motor Corp., New York

GRIFFIN, PERLEY K., Mech. Draftsman, Stone & Webster Engrg. Corp., Cambridge, Mass.

HERRICK, DANIEL A., Supt., Julian D'Este Co., Boston, Mass.

HURXTHAL, ALPHEUS O., with The Lunkenheimer Co., Boston, Mass.

KEHOE, BASIL T., Genl. Foreman, Stirling Drum Dept., The Babcock & Wilcox Co., Barberton, Ohio

LAZEAR, WESTON B., Mech. Engr. New York Office, Stephens-Adamson Mfg. Co., New York

LEFFLER, LEO J., Secy., Chas. Leffler & Co., Brooklyn, N. Y.

LESERMAN, PHILIP, JR., Cons. Engr., also Owner, The Supervision Co., New York

McLUNDIE, ARCHIBALD S., Mech. Engr. and Patent Atty., Chattanooga, Tenn.

O'CONNOR, JOHN B., Designer, Lyon Metallic Mfg. Co., Aurora, Ill.

PAPWORTH, WALTER A., Supt., Corona Typewriter Co., Groton, N. Y.

QUAYLE, LEROY A., Asst. Engr. of Pwr., Dept. of Public Utilities, Div. of Water, City of Cleveland, Ohio

SCHMIDT, JOHAN C. C., Engr. and Draftsman, Ransome Concrete Mchy. Co., Dunellen, N. J.

Scott, George W., Genl. Foreman, Scott & Sons' Co., Medford, Mass.

Scott, W. Doke, Engrg. Asst., Syracuse Ltg. Co., Syracuse, N. Y.

Smith, Walter J., Genl. Mgr., Lightwell Steel Sash Co., Newport, Del.

Streeter, Claude O., Asst. Sales and Cons. Engr., Graton & Knight Mfg. Co., Worcester, Mass.

Stringfellow, Henry A. Head of Dept. Civil Engrg., Mechs. Inst., Rochester, N. Y.

Sweet, Steven H., The Hitchcock Gas Eng. Co., Bridgeport, Conn.

Thorpe, George H., Designing Engr., Millville Mfg. Co., Millville, N. J.

Udale, Stanley M., Lab. Engr., Holley Bros., Detroit, Mich.

Vallance, Alexander, Instr. in Theo. and Applied Mechs., Univ. of Ill., Urbana, Ill.

Walsh, William J., Plant Supt., Fayette R. Plumb, Inc., Philadelphia, Pa.

Wells, Meurice T., with Pratt & Inman, Worcester, Mass.

Williams, Richard C., with Buffalo Steam Pump Co., Buffalo, N. Y.

Wilson, Alfred B., Local Coml. Mgr., New York Telephone Co., Plainfield, N. J.

Young, John M., Mech. Engr., Otis Elevator Co., Buffalo, N. Y.

FOR CONSIDERATION AS JUNIOR

Agnew, James R., Ch. Engr., City of Clarksdale Municipal Pwr. Plant, Clarksdale, Miss.

Alden, Roger O., Toolmaker, Bausch Machine-Tool Co., Springfield, Mass.

Ballou, Joseph L., Insptr., Chicago Telephone Co., Chicago, Ill.

Bassett, Cyrus W., Engr., Elevator Supply & Repair Co., Chicago, Ill.

Blake, Frank C., Instr., Mech. Engrg., Brown Univ., Providence, R. I.

Brady, Laban J., Grad. Student 1915, Univ. Colo., Kansas City, Mo.

Burnell, Alfred E., Draftsman, Taylor-Wharton Iron & Steel Co., High Bridge, N. J.

Chace, Howard P., with Norton Grinding Co., Worcester, Mass.

Cole, Frank H., Head of Chem. Dept., Walworth Mfg. Co., Boston, Mass.

Colvin, James A., with Sauk Rapids Granite Co., Sauk Rapids, Minn.

Epstein, Meyer K., with Gilbert & Barker Mfg. Co., Springfield, Mass.

Fenn, John G., Supvrg. Insptr., London Guarantee & Accident Co. Ltd., New York

Fisher, Robert R., with Albaugh-Dover Co., Chicago, Ill.

Frauens, Frank H., Jr., Supvr. of Constr., W. B. Rollins & Co., Cons. Engrs., Kansas City, Mo.

Loeb, Alfred H., Rolled Wheel Dept., Midvale Steel Co., Philadelphia, Pa.

Luehrmann, Hugh, with The Babcock & Wilcox Co., Cincinnati, Ohio

Main, Charles C., Jr., with Brunner Mfg. Co., Utica, N. Y.

Miller, Lyman H., with American Steel & Wire Co., Worcester, Mass.

Mueller, Jacob L., Experimental Engr., Springfield Facing Co., Springfield, Mass.

Neff, Russell M., with David Luptons' Sons Co., Philadelphia, Pa.

Noble, Robert E., Designing Mech. Engr., Mesta Mch. Co., Pittsburgh, Pa.

Patten, Ernest L. O., Mech. Engr., Katahdin Pulp & Paper Co., Lincoln, Me.

Pearce, Edwin S., Specl. Engr., Chicago, Cleveland, Cincinnati & St. Louis Rwy., Indianapolis, Ind.

Perry, Ralph H., Mech. Engr., Katahdin Pulp & Paper Co., Lincoln, Me.

Renton, James L., Shop Foreman, Ewa Plantation Co., Ewa, Hawaii

Richon, Jules L., Betterment Dept., Robert Gair Co., Brooklyn, N. Y.

Rowlands, Richard A., Engrg. Dept., The Babcock & Wilcox Co., Barberton, Ohio

Rubin, Harry E. with The National Dry Kiln Co., Indianapolis, Ind.

Schlenker, Rudolf P., Mech. Draftsman, Bath Iron Wks., Bath, Me.

Schlank, Elias, Engr., M. W. Kellogg Co., Jersey City, N. J., and New York

Schmidt, Francis W., Engr., West Penn Traction Co., Pittsburgh, Pa.

Schneider, Louis J., with Hyatt Roller Bearing Co., Detroit, Mich.

Sheatsley, Paul W., Grad. 1915, Ohio State Univ., Columbus, Ohio

Voigt, Louesther S., Foreman Reinforced Concrete Constr., with Wm. E. Cory, Civ. Engr., Sedalia, Mo.

Wieber, George A., Student App., Westinghouse Mch. Co., East Pittsburgh, Pa.

Young, Charles M., Engr. Draftsman, Thomas Potter Sons & Co., Inc., Philadelphia, Pa.

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM ASSOCIATE-MEMBER

Nichols, Frederick C., Asst. Engr., The Panama Canal, Balboa Heights, C. Z.

PROMOTION FROM JUNIOR

Gilman, Franklin W., Testing Engr., Sanford Riley Stoker Co. Ltd., Worcester, Mass.

Martin, Edward J., Asst. Supt., Hopkins & Allen Arms Co., Norwich, Conn.

Renner, Roland B., Charge of Engrg., Jeffrey Mfg. Co., New York

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ICE-MAKING AS A BY-PRODUCT OF CENTRAL STATIONS

BY HEYWOOD COCHRAN,[1] CHICAGO, ILL.

Non-Member

ALTHOUGH ice plants have been operated in connection with electric light plants for a considerable time, it is only within the past five years that the possibilities for profit in such a combination are beginning to be appreciated. These ice plants may be conducted in either of two ways: *First,* as the property of the central station, in which case they are usually located adjacent to the power plant; *Second,* privately owned, purchasing current or steam from the central station. The latter are usually motor driven compression plants, located at the point best adapted for the distribution of ice.

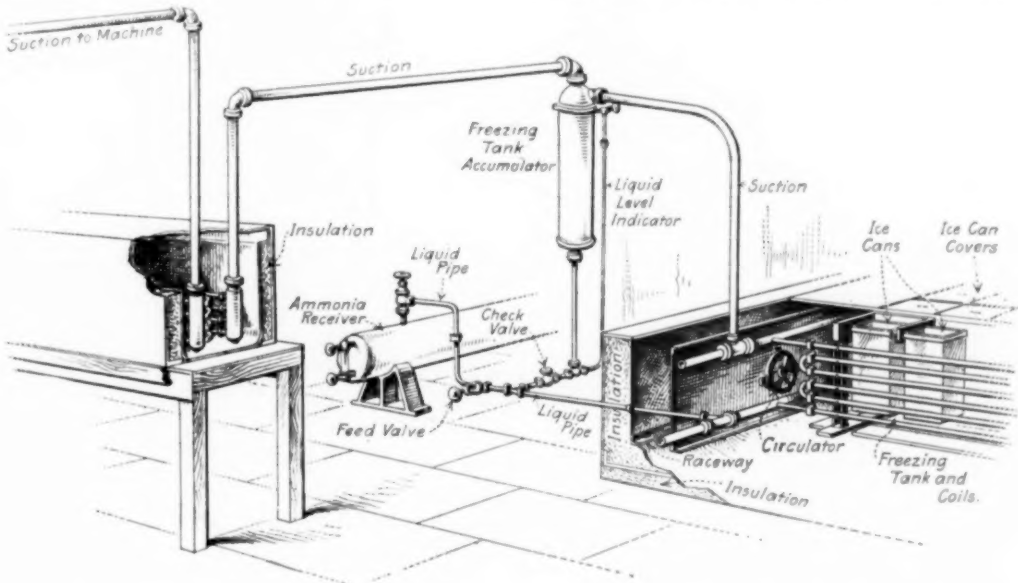

Fig. 1 Diagrammatic View of a Section of a Modern Ice Tank of the Flooded Type

One point of difference between electric light and ice plants is the limit of size for economical distribution. For the former this is indefinite, but the latter soon reach a size where the cost of distribution more than offsets the saving from a central plant. There are in operation plants of 300 to 500 tons capacity, but individual plants of from 80 to 150 tons capacity are preferable. Except for the cost of distribution, however, a plant owned by a central station if properly designed can make ice cheaper than any ice plant in the second class or any other privately owned plant.

In order to explain why certain kinds of ice machines are better adapted for the first class and others for the second, a brief description of the methods of ice manufacture will be given. While there are a number of different refrigerants, only ammonia will be considered, as it can be used in both compression and absorption ice machines. Ammonia, as is well known, is a gas at atmospheric pressure and all ordinary temperatures, but it may be liquefied by compression, the pressure required depending upon the amount of condensing surface, type of condenser and temperature and amount of condensing water available. The liquid, usually known as "liquid anhydrous" (although it is not always anhydrous), must then absorb heat before it can again become a gas.

Fig. 1 shows a section of a modern ice tank of the "flooded" type. The liquid anhydrous passes from the ammonia condensers into the receiver on the left and then enters the coils in the tank at the bottom, through a valve known as the "expansion valve." The ice cans are filled with water and the surrounding space with brine. The liquid anhydrous in the coils absorbs heat from the brine, which in turn absorbs heat from the water in the cans, taking up 142 B. t. u. from every pound of water at 32 deg. in order to form ice at the same temperature. The resultant gas is removed from the coils to be recondensed and it is in this process alone that the absorption and compression systems differ.

While in the compression system the ammonia gas is mechanically sucked out of the coils by a compressor, in the absorption system, it is sucked out by its strong attraction for water, making aqua ammonia. An absorption machine involves the use of heat exchanging apparatus comprising absorber, generator, etc., as indicated in Fig. 2, which shows a typical absorption machine of the double pipe and tubular type. Here the expanded gas is to be removed from brine cooler coils. The absorber, which is the heart of the system, is built like a horizontal tubular boiler, with 2 in. tubes through which cooling water passes. Weak aqua, which has had a part of its gas driven off, enters the top. On the suction stroke of the machine the gas bubbles up through this weak aqua, changing it into strong aqua, which is pumped into the ammonia boiler or generator, where steam passing through coils drives off the gas and produces sufficient pres-

[1] Western Manager, Carbondale Machine Co.

Presented at the Chicago local section of The American Society of Mechanical Engineers, March 19, 1915.

sure to condense it. The rectifier is a drier and the exchanger is the feed water heater of the system. The aqua pump, which is the only moving part, requires about $^{1}/_{10}$ h.p. per ton of ice and can be driven either by steam or motor. The action of the generator in this case takes the place of the compression stroke. Instead of having only one cycle as in the compression system, there are two, the strong and weak aqua cycle being the second.

Thus the compression machine requires power only while the absorption machine requires practically heat only, and a highly economical ice plant can be made by a combination of the two systems, especially if raw water ice is made as in the case of the electrically driven compression plant. With cold condensing water, say under 70 deg., it is possible to use exhaust steam at 3 lb. pressure in the generator. This steam is condensed, furnishing a portion of the distilled water required for making ice. About 55 to 60 lb. of steam per hour per ton of ice are required for this purpose. With condensing water of 90 to 95 deg. it is not possible to run on less than from 20 to 25 lb. exhaust steam pressure, because of the high condensing pressures necessary. Such pressures would seem prohibitive and yet a plant will be described later which is proving very economical under those conditions.

The absorption machine is the ideal one for warm water conditions when properly designed. Just as it takes very little more coal to carry 125 lb. pressure than 100 lb. (less than 1 per cent), it takes comparatively little more steam in the generator to produce 200 lb. pressure than it does 150 lb. The increase in power required for a compression machine, however, is very marked. An electrically driven compression plant will require from 43 to 70 kw-hr. per ton of ice per day, depending upon its size and other conditions. The former figure can hardly be called normal. At 1 cent per kw-hr. the power costs per ton will usually average between 50 and 60 cents. Table 2 gives figures showing the operating cost of compression machines using various sources of power including electricity. This gives $58\frac{1}{2}$ kw-hr. as the amount of current required for all purposes.

From the central station manager's standpoint in the larger cities, such as Chicago, the privately owned, electrically-driven ice plant is the proper combination, while in the smaller cities, he will find it much more profitable to own the ice plant direct. Whether it is more profitable in the larger cities from the ice plant manager's standpoint to purchase current at a power cost of 50 cents per ton or over is very questionable and will depend largely upon circumstances. Some figures from an independent exhaust-steam ice plant will be of interest.

Table 1 gives the coal cost per ton on ice made in such a plant with coal at \$1.80 per ton. The coal used was of various kinds, although that at \$1.80 per ton was Indiana No. 4. All ice was made from distilled water. The coal cost per ton is only 20 cents. Adding the fireman's wages and interest and

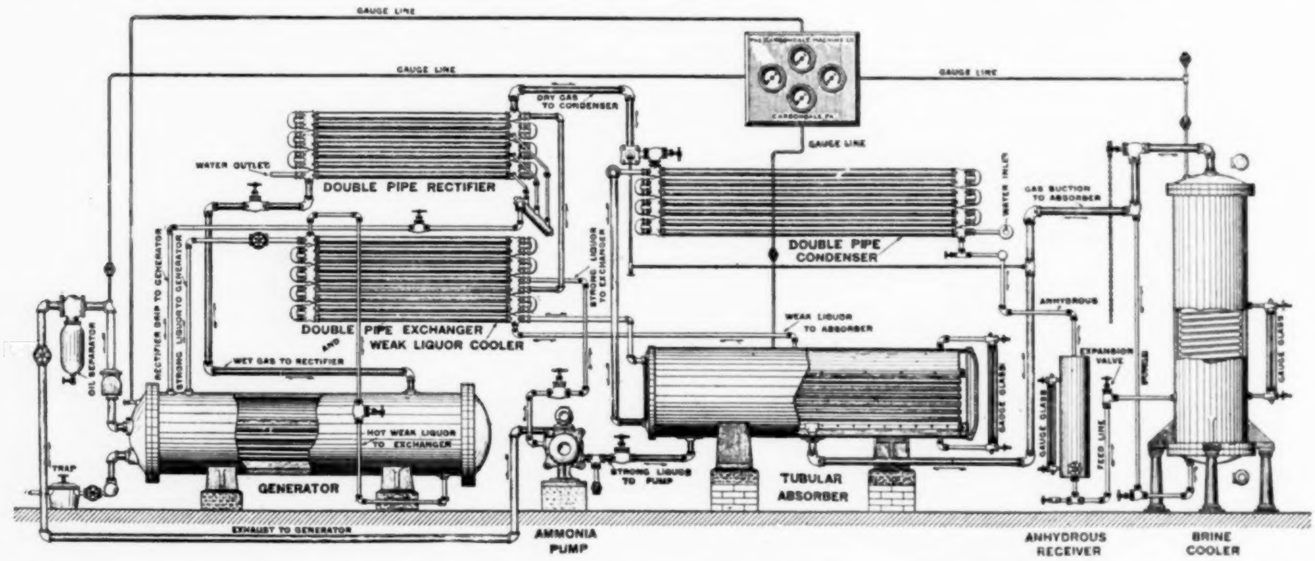

Fig. 2 Diagram showing General Arrangement of a Typical Absorption Refrigerating Machine of the Tubular Type

TABLE 1 COAL AND ICE RECORDS, MUNCIE ICE & COAL CO. MUNCIE, IND.

Aug. 1912 Date	Day or Night	Kind of Coal	No. 400 lb. Cakes	Pounds Ice Made	Pounds Coal Burned	Ratio	Ave. Ratio	Ave. Fuel Cost
18	Day	Indiana No. 4	152	60800	6860	8.7	8.7	
18	Night	at \$1.80 per ton	141	56400	6491	8.7	8.7	
19	Day	"	150	60000	6357	9.4	8.93	
19	Night	"	150	60000	6896	8.7	8.88	
20	Day	"	150	60000	6685	9.0	8.9	
20	Night	"	150	60000	6476	9.2	8.95	
21	Day	"	150	60000	7101	8.4	8.87	
21	Night	"	150	60000	6689	9.0	8.89	
22	Day	"	150	60000	6975	8.6	8.86	
22	Night	"	150	60000	6661	9.0	8.87	
23	Day	"	150	60000	6945	8.6	8.84	
23	Night	"	141	56400	6805	8.3	8.8	
24	Day	"	160	64000	6937	9.2	8.83	
24	Night	"	154	61600	6625	9.3	8.86	
25	Day	"	145	58000	6863	8.7	8.85	
25	Night	"	150	60000	6673	9.0	8.86	
Average			149½	59825	6752		8.86	\$0.203

depreciation on the boiler plant, the total power cost should not exceed 35 cents.

It is entirely possible, however, in a properly designed compression and absorption plant, say of 80 tons capacity, with a 20 ton machine of the former type and a 60 ton of the latter, to make ice at a fuel cost even lower. In this case, there should be two 40 ton tanks, the compression machine being used on one-half the coils of one tank and the absorption machine on the others. The exhaust from the compression engine and auxiliaries furnishes the 3600 lb. of steam per hour required for the generator and the absorption machine, making raw water ice with coal at $2.00 per ton, at an evaporative efficiency of only 6 to 1; 6½ tons are required and the fuel cost is 16 cents per ton. Such an 80 ton plant could be run on a 125 h.p. boiler and with a second boiler in reserve, the cost, including interest and depreciation, etc., and labor will hardly be more than 30 cents per ton, if that. There will be plenty of distilled water for filling cores, and distilled water ice can be made at a slightly increased cost.

Of course, if a suitable neighbor could be found requiring a certain amount of power and heat and having no use for the exhaust steam, a straight 80 ton absorption machine could be installed. By using the expansive force of the 4800 lb. of steam per hour, required by the generator, in an economical uniflow engine, current could be sold, not bought, which would further reduce the operating cost.

To show the possibilities for profit in a properly designed combination plant, owned by a central station, reference will be made to a plant in a southern city of about 50,000 inhabitants, where the conditions are so trying that if a combination plant can prove profitable there, it would anywhere. This plant was installed in 1912, under the direction of Sargent & Lundy, consulting engineers of Chicago, and has proved satisfactory to all concerned.

The old company had been in the ice business for a number of years, having a 50 ton compression machine with two 25 ton tanks, each containing 412 - 300 lb. cans. At one end of the old building they also had a 2,000 ton storage house which had never been insulated or used. In addition they owned a second compression ice plant with independent steam plant, of 25 tons capacity, located a mile or more away and operated as a separate unit from May to September. A spray pond was used for cooling condensing water for both the condensing engine and the ice machine. The fact

TABLE 2 COST OF MANUFACTURING RAW-WATER ICE—100 TONS CAPACITY—VARIOUS SOURCES OF POWER

(From General Electric Review, July 1914)

	Motive Power	Using	h.p.	Total h.p.-Per hr. Day	Fuel per h.p.	Fuel or Power Per Day	Unit Cost of Fuel	Fuel Cost per Day	Tons of Ice per Unit of Fuel	Sundry Costs			Labor Cost					Total Cost per Day	Cost per h. p. of Power Plant
										Oil Waste, Etc.	Ammonia	Calcium	1 Day Engineer	1 Night Engineer	4 Ice Pullers	1 Extra Man	2 Firemen		
1	Simple Steam Engine	Bituminous Coal	367 i.h.p.	8808	3½ lb.	15.4 tons	2.00 tons 2.50 tons 3.00 tons	$30.80 38.50 46.20	6.38 Tons Ice per Ton of Coal	2.00	2.50	0.50	5.00	3.25	8.00	2.00	5.00	$59.05 66.75 74.45	$32.00
2	Compound Condensing Engine	Bituminous Coal	375 i.h.p.	8952	2 lb.	8.95 tons	2.00 tons 2.50 tons 3.00 tons	17.90 22.38 26.85	11.15	3.50	2.50	0.50	5.00	3.25	8.00	2.00	5.00	46.15 50.63 55.10	40.00
3	Producer Gas Engine	Bituminous Coal	360 b.h.p.	8640	1¼ lb.	5.4 tons	2.00 tons 2.50 tons 3.00 tons	10.80 13.50 16.20	18.5	3.50	2.50	0.50	6.00	4.00	8.00	2.00	4.00	*41.30 44.00 46.70	65.00
4	Producer Gas Engine	Anthracite Coal	360 b.h.p.	8640	1 lb.	4.31 tons	3.00 tons 3.50 tons 4.00 tons 4.50 tons 5.00 tons 5.50 tons 6.00 tons	12.93 15.09 17.24 19.40 21.55 23.71 25.86	23.2	3.50	2.50	0.50	6.00	4.00	8.00	2.00	4.00	43.43 45.59 47.74 49.90 52.05 54.21 56.36	65.00
5	Producer Gas Engine	Lignite	360 b.h.p.	8640	1¾ lb.	7.56 tons	2.00 tons 2.50 tons 3.00 tons	15.12 18.90 22.68	13.2	3.50	2.50	0.50	6.00	4.00	8.00	2.00	4.00	45.62 49.20 53.18	65.00
6	Gas Engine	Natural Gas 1050 B.t.u. Value	360 b.h.p.	8640	10 cu. ft.	86400 cu. ft.	0.20 per M 0.25 per M 0.30 per M 0.35 per M	17.28 21.60 25.92 30.24	864 cu. ft. gas req'd per Ton of Ice produced	3.50	2.50	0.50	6.00	4.00	8.00	2.00		43.78 48.10 52.42 56.74	35.00
7	Oil Engine	Fuel Oil	360 b.h.p	8640	0.075 gal.	648 gal.	0.02½ gal. 0.03 gal. 0.03½ gal. 0.04 gal.	16.20 19.44 22.68 25.92	.155 Tons Ice per Gal. of Oil	3.50	2.50	0.50	6.00	4.00	8.00	2.00	4.00	46.70 49.94 53.18 56.42	40.00 to 60.00
8	Motor	Electricity	327 on wire	7848	0.746 kw.	5854 kw.	0.00½ kw. 0.00⅝ kw. 0.00¾ kw. 0.00⅞ kw. 0.01 kw.	29.27 36.48 43.90 51.23 58.54	58.54 kw-hr. req'd per Ton of Ice produced	2.00	2.50	0.50	5.00	3.25	8.00	2.00		47.51 59.63 67.15 74.48 †81.79	16.00

Water estimated at 70 deg. fahr. Suction pressure 15 lb. Power included for pumping water with 60 foot head. * Minimum.
Condenser pressure 185 lb. Ammonia used as refrigerant. † Maximum.
Above costs do not include interest on investment, depreciation, taxes, insurance, management or any other fixed charges. Power is based on summer conditions. Less power will be required if yearly average is figured on. Oil engine fuel requirements based on engines of Diesel type.

that the temperature of this water reached 95 deg. and sometimes over, had greatly reduced the output of the 50 ton plant as well as increased the cost of manufacture. In fact, hardly more than 38 to 40 tons of ice had been made daily on the two tanks previously mentioned, and the operating cost was considerably over $2.00 per ton. It is only fair to say, however, that as the new owners contemplated a change, the plant was not in as good condition as it should have been.

It was decided to increase the output to 100 tons and the original plans contemplated the addition of 50 tons more tank capacity and either electrically driven compression machines at the old plant, or compound condensing machines of 100 tons capacity at the new. The engineers, however, wisely decided to insulate the ice storage house which would give 40 tons extra capacity daily for fifty days, during the summer peak, and they put in an exhaust steam Carbondale machine of the atmospheric type, guaranteed to make 60 tons of ice on the two tanks and cool the storage house. The old 25 ton plant was abandoned and sold. The condensers, absorbers, weak liquor coolers and rectifiers are located on the boiler house roof of the new plant. In this connection, it may be of interest to know that this exhaust steam machine was added without increasing the size of the power plant building, while same would have had to be extended at a cost of $12,000.00 if a compound condensing compression machine had been selected. Preliminary estimates showed that ice could be made in this plant at an operating cost not exceeding 45 cents per ton.

Fig. 4 is an interior view of the turbine room in the new power house, showing one of the two 2500 kw. turbines which, of course, is run condensing. In the foreground is a 75 h.p. Terry turbine direct connected to a centrifugal water

FIG. 3 EXTERIOR OF POWER PLANT SHOWING LOCATION OF ATMOSPHERIC APPARATUS ON THE ROOF

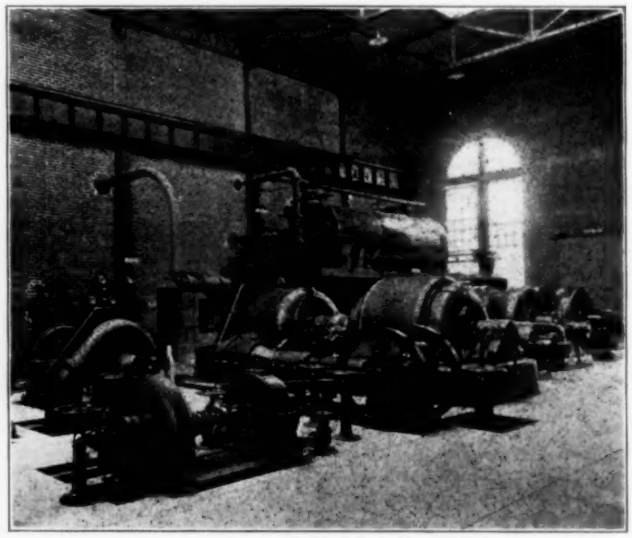

FIG. 4 INTERIOR OF THE TURBINE ROOM SHOWING AMMONIA GENERATOR ON GALLERY

TABLE 3 ICE PRODUCED AND SOLD BY A COMPANY IN A SOUTHERN CITY DURING THE PAST SEVEN YEARS

	Tons Manufactured								Tons Sold							
	1907	1908	1909	1910	1911	1912	1913	1914	1907	1908	1909	1910	1911	1912	1913	1914
January	124	292	..	100	289	110	1497	728	431	280	341	228	301	129	1256	714
February	158	263	..	211	330	162	1437	1148	251	248	321	182	308	135	943	518
March	1170	681	121	464	393	261	1215	2293	592	548	406	423	346	22[illegible]	991	707
April	1604	778	1052	612	498	246	1236	2209	527	700	609	532	486	530	1170	966
May	1177	1248	1513	799	1106	..	1959	1876	1119	1167	921	823	1363	971	1743	1603
June	1277	1991	1393	1051	1859	..	2012	1977	1291	1797	1290	1199	1721	1223	2014	2964
July	2219	1995	432	1117	1747	..	2134	2125	2212	2011	381	1260	1748	1603	2682	2137
August	2110	1901	1114	1873	1389	1333	2178	2156	1976	2031	1541	1691	1800	1529	2565	3229
September	1728	1666	400	1073	1238	1836	1773	2035	1634	1797	552	936	1522	1625	2027	2570
October	699	776	112	902	977	1462	1452	2173	843	980	218	849	948	1107	1401	1698
November	..	568	567	353	382	1068	814	1845	484	564	524	408	327	825	725	1271
December	83	755	291	301	320	1250	801	1462	347	458	282	263	276	774	773	777
Total	12349	12814	6997	8856	10528	7728	18508	22027	11707	12581	7386	8794	11145	10672	18290	19154
Increase	..	465	..	1859	1672	..	10780	3519	..	874	..	1408	2351	..	7618	864
Decrease	..	..	*5817	..	..	**2800	..	..	..	..	5195	..	..	473	..	..
Per Cent Increase	..	3.7	..	26	19	..	139	19	..	7.4	..	19	26	..	71	4
Per Cent Decrease	..	..	45	..	..	26	..	..	..	..	41	..	..	4	..	..

* Enlargement of ice storage necessitated purchase of abnormal amount of ice in order that the house would be filled before the summer season.
** Plant No. 1 broken down and tank room being overhauled. Plant No. 2 was inoperative necessitating purchasing practically entire supply.

circulating pump, which was designed to run to its capacity with 200 lb. steam pressure and 25 lb. back pressure; under these conditions, it was guaranteed to use 70 lb. of steam per h.p.-hour, just 20 lb. more than if it had exhausted at atmospheric pressure into the feed water heater. This is somewhat more steam than the generator requires, and the excess is used in the heater.

Fig. 5 is a near view of the ammonia generator, showing the aqua pumps beneath and the aqua receiver at one side. One of these small pumps is capable of making 75 tons of ice, is automatically controlled and requires little attention. In fact, outside that of pulling and storing the ice, the labor cost in the plant is practically eliminated. The exchangers of the vertical shell type are on the other side of the wall, back of the boilers. All the rest of the machine is on the boiler house roof.

Fig. 6 shows this atmospheric apparatus. There are 28 combined condenser and absorber stands of which the upper

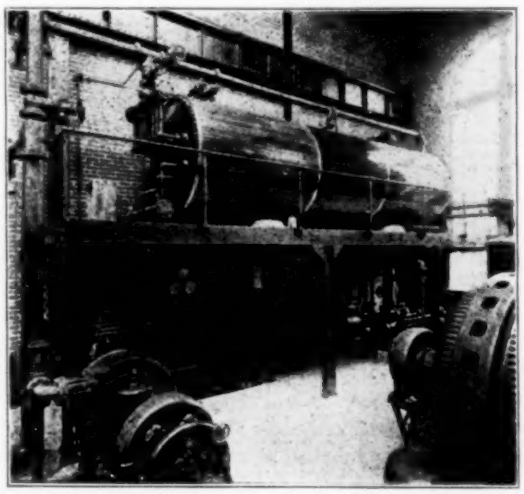

FIG. 5 NEAR VIEW OF THE AMMONIA GENERATOR SHOWING AQUA PUMPS UNDERNEATH

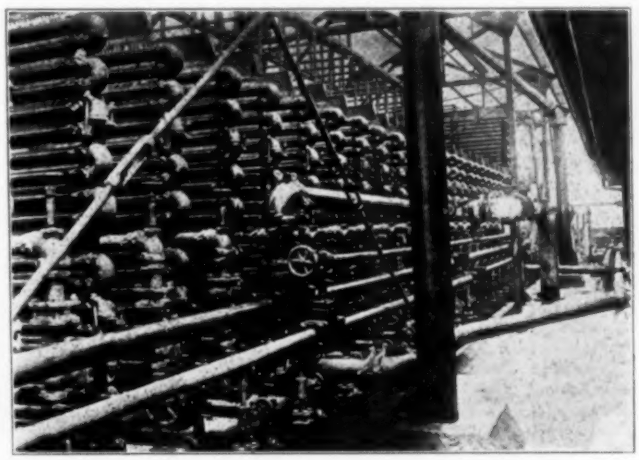

FIG. 6 VIEW OF THE ATMOSPHERIC ARRANGEMENT OF CONDENSER AND ABSORBER STANDS

ten pipes are condensers and the lower twelve absorbers. The rectifiers and weak liquor coolers can be seen in the rear. The weak liquor enters the mixer through a jet helping to pull in the gas. During the winter one-half of these stands will make capacity and only 55 lb. pressure is required on the generator, materially reducing the steam consumption.

Table 3 shows the ice produced and sold for the past seven years by this company, the new machinery having been started August 10, 1912. In this connection, it should be remembered that up to 1912 the figures include the output of the 25 ton independent plant.

In January 1914 the roof of the storage house was raised so that ice can be piled 60 ft. high, increasing the capacity to 5,000 tons. In spite of this extra refrigerating load, the plant averaged 70 tons of ice during the hot summer months and 60 tons for 365 days. The credit of this is due, not only to the machine, but to the fact of unusually capable management.

Table 4 shows the output and operating cost for 1914. Even with 95 deg. water and a tank 500 ft. away from the machine the entire average operating cost for the year is less than the power cost alone in the privately owned electrically-driven compression plant. Table 5 shows the detail of the 41 cents per ton operating cost.

As a rule, it is better to figure on obtaining steam for the generator from one or more of the auxiliaries as in this case. If at times the supply is insufficient, live steam can be admitted through a pressure reducing valve, but it doesn't pay to put back pressure on a large engine for a small ice plant.

With well water, it is entirely possible to operate the generator on from $\frac{1}{2}$ to 3 lb. pressure. While it is perhaps advisable to use the exhaust from the auxiliaries in condensing plants in all cases, it is entirely possible to bleed sufficient steam from an intermediate stage of a condensing turbine. A 2500 kw. turbine, running at full load with $27\frac{1}{2}$ in. vacuum, used 14.85 lb. of steam per kw.-hr. When the turbine was operated under the same conditions, except that 5000 lb. of steam was extracted per hour, at from 2 to 5 lb. pressure, 16.32 lb. was used. This is an increase of 3675 lb. per hour and, as this 5000 lb. of steam so extracted will make 85 tons of ice, the extra steam would amount to 43 lb. per ton of ice per hour. This is over twice the extra steam required from the plant just described. If the above engine is operated at half load, and 5000 lb. of steam per hour is extracted, 16.8 lb. will be used. This will be 2437 lb.

TABLE 4 PRODUCTION DATA FOR CALENDAR YEAR 1914

Month	Tons Mfg.	Cost per Ton Mfg.
January	728	$.35
February	1148	.33
March	2293	.27
April	2209	.33
May	1876	.46
June	1977	.42
July	2125	.45
August	2156	.42
September	2035	.42
October	2173	.451
November	1845	.461
December	1462	.4792
Total,	22027	$.4062

of steam extra or $28\frac{1}{2}$ lb. per ton of ice per hour. It is, therefore, more economical to bleed such a condensing turbine at half rather than full load, but in neither case as economical as where exhaust is taken from non-condensing auxiliaries.

If the turbine had been running at full capacity condensing and the current used for driving an electrically-driven compression machine, about the same amount of extra steam would be taken from the boilers to make 85 tons of ice as would be required for an absorption machine of this capacity bleeding steam from the turbine. However, in the first case, the output of the turbine would be decreased by the amount of current used, while in the latter its entire capacity would be available for commercial purposes.

In conclusion, it may be said that central station managers, owning their own ice plants, where properly designed, are finding such plants far more profitable than the lighting plant itself. In fact, in some of the smaller cities, where the light plant was operated alone at a loss, the combination has turned the same into a source of profit. In many small towns the water and light plants are combined, in which cases the water is first used for the ice machine and afterwards turned into the city mains. There can be no question about the future of the properly designed combination plant.

TABLE 5 ICE STATEMENT FOR CALENDAR YEAR 1914

	Year Ending 12-31-14	Per Ton Made
Station wages	\$2793.38	.13
Fuel	2498.11	.11
Water	910.22	.04
Lubricants	36.90	...
Supplies and expenses	315.86	.01
Salt and ammonia	424.91	.02
Maintenance buildings	239.07	.01
Maintenance equipment	521.25	.03
Power bought	1208.10	.06
Total production	\$8947.80	.41

DISCUSSION

E. W. LLOYD[1] in discussing this paper said that three or four years ago when it became necessary for the central stations in Chicago to secure additional power loads in order to meet a new rate schedule, the refrigerating business presented itself as the most promising. Experience has justified this promise and in the past three years the number of plants thus operated has been increased from one to eighteen, and at present a third of a million tons of ice, or ten per cent of the city's total requirements, is being made with central station power. The chief interest is in raw water ice plants which are the best where the public water supply is pure. The annual load factor is about 45 per cent, though in exceptional cases it may rise to 65 per cent. The kilowatt hours per ton is quite variable, depending somewhat on the size of the cans. Experiments are now being made to determine the best ratio. We sell power for ice making at one cent per kw.-hr., which is feasible on account of the low increment cost of taking on the business of this class.

[1] Commonwealth Edison Co., Chicago.

SOME ENGINEERING PROBLEMS ARISING IN THE TRANSPORTATION OF NATURAL GAS

BY JAS. P. FISHER, BARTLESVILLE, OKLA.

Member of the Society

NATURAL gas occurs in certain portions of certain strata of the earth's surface in areas of comparatively limited extent. It is used as fuel, for the most part, in centers of population and industrial activity. The fields where the gas is found usually happen to be at considerable distances from the points of consumption, making it necessary to lay pipe lines for transporting the gas. The designing, building and operation of these transportation systems give rise to many problems of an engineering nature.

In the earlier stages of the industry, the greatest difficulty was experienced in constructing a pipe line sufficiently good and cheap to make the commercial transportation of gas feasible for any great distances. As better pipe line, pipe couplings, compressing equipment and measuring equipment have been developed, it has been made possible to transport gas successfully over greater and greater distances. The limits in improvement in equipment and in knowledge of conditions have not yet been reached by any means, so that the present distances of transportation are in no way final.

In the beginnings of the industry no supply of suitable pipe was available, and the joints between sections were so imperfect and prone to leak that it was found commercially impracticable to transport gas through a pipe for more than a very few miles. Various types of pipe lines were tried. Some lines were laid with cast iron pipe, with bell and spigot joints calked with lead. These lines were fairly good for moderate pressure, but were very expensive to lay. Their high cost and the proportionately low pressures permissible made them unsuitable for any great length.

Lines of steel or wrought iron pipe with screw joints were the first used to any large extent. In some of the earlier lines, the joints were made with a straight thread; but it was very soon found that the taper thread was greatly superior, both in strength and tightness. Some very extensive transportation systems were laid with pipe joined in this way, but a number of serious difficulties arose, the greatest of which was that of making a line reasonably free from leakage. This leakage became greater with increase in length of line, and also with increase in pressures carried, and put a commercial limit on the distance that it was profitable to transport gas.

When it was necessary to increase the carrying capacity of a line, pipe of larger diameter was laid without attempting to materially increase the pressure carried. This led, in some instances, to lines of enormous diameter. One line was laid into Pittsburgh 36 in. in diameter, of steel riveted pipe joined by flanges throughout its length. Such construction was exceedingly costly; and, when it is remembered that the field to which a line was laid might not last more than a few years, it is seen that a better arrangement

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of pipe line was very badly needed. It was not found practicable to make threaded joints in pipe larger than 12 or 14 in. in diameter, and even in pipe of this size it was found to be difficult to make tight joints.

Several different types of wrought iron pipe joints made by calking with lead were tried. Lines laid with such joints were tight at first, but any motion of the pipe from settling of the soil or temperature changes was found to make them leak badly.

Temperature changes were also found to be a destructive element in a line of pipe connected by threaded joints. Lines laid in the summer often pulled apart in the winter. Where such joints are now used, the lines are laid in cold weather if possible.

To meet these difficulties a new type of coupling was developed, consisting of a center piece, which slipped over the ends of the two lengths of pipe to be joined, two glands or end rings, two rubber packers, and connecting bolts between the two end rings, the whole forming a double stuffing box arrangement. This coupling proved to possess many advantages over any form of joint previously used, and with it lines that were very nearly free from leaks, if sufficient care was taken in their construction, were found possible. Lines could also be made of lighter pipe and still carry the same or higher pressures than was possible with the threaded joint. This improvement has greatly increased the distance it is possible to transport gas profitably; and, although the joint has many grave weaknesses, it is the best available at the present time.

Recently there have been some short lines laid in which the pipe was welded together end to end. This practice is too new to prove its success, but it seems to promise the solution of difficulties due to leakage and deterioration of the rubber-packed joints now commonly used. Like pipe joined by screw joints, the line will be subjected to heavy strains due to temperature changes, and it is likely that special provisions in expansion joints will have to be made for this condition.

In the early days, the natural pressure of the gas as it occurred in the fields was the source of power used for its transportation. As the fields neared exhaustion, or when the distances from the fields to the points of consumption were too large, the pressure fell too low, and it became necessary to increase it artificially by means of compressors of one type or another. In many of the earlier plants attempts were made to locate these compressors in the towns and draw the gas through the lines by suction. As could have been easily predicted theoretically, these attempts failed, and it became the practice to locate the stations in or near the fields. At the present time practically every gas transportation company has to keep up a system of compressing stations in order to properly maintain and control the amount of gas passing through its lines.

Most of the larger natural gas systems of the country have been the result of a process of evolution in which lines were extended farther and farther to reach one field after another, and in which one compressing station after another has been built, usually for the purpose of putting gas from a declining local field into the main trunk line. Another factor in this evolution has been the necessity of small companies combining in order to be able to go to greater distances for a common additional supply when the old sources of supply were exhausted. As conditions have changed, some of the equipment becomes useless in its present location, and sometimes it is possible to so alter lines as to utilize old equipment for a new purpose.

The Cushing field is one of the main sources of supply in the mid-continental region. When first developed this promised to be a long-lived source of supply. At that time, however, the gas was found mostly in the Wheeler Sand, at a depth of about 1500 ft., and some oil was found with it. The presence of oil in a field is always somewhat of a menace to the life of the field as a gas supply. This is largely because it is cheaper and easier to produce the oil and allow the gas to waste to atmosphere. When oil wells are so situated as not to be convenient to a gas line, the gas is not marketable, and is considered as a by-product of small value by the oil man. In a great many instances oil can be produced without pumping by simply allowing the gas pressure to blow it out.

In the Cushing field, oil and gas were discovered in a deeper sand several months after the taking of gas from the field had been begun. This caused an exceedingly active development of the deeper sand for oil, and enormous quantities of gas were allowed to waste to the air. Not only this, but in a great many instances the wells were so carelessly cased and packed that the higher pressure gas in the deep sand followed up around the casing to the lower pressure strata above, where it was dissipated and was no longer available for commercial purposes. By proper means, it is possible to drill the oil wells and produce the oil with scarcely any waste of gas, but it costs more.

It is estimated that the gas escaping from the Cushing field is about 400,000,000 cu. ft. per day, or about 11,000 tons per day. This would be equivalent in fuel value to a train load of coal of 300 to 400 cars of average capacity. Of the gas in this field, only about 10 per cent ever gets into a pipe line or is used as fuel. The problem here is mostly one of proper government and control, so far as the community at large is concerned, and financial, so far as the transportation company is concerned.

As the gas in the Cushing field comes from the well, it is very far from pure or a perfect gas. It is composed largely of methane, with considerable quantities of the heavier hydrocarbons, ranging from ethane through the C_nH_{2n+2} series, including those which at ordinary atmosphere conditions are vapors and are considered as part of the gas proper, down to heavy oils, and often salt water. The liquids are held in suspension as a fog or mist, or run along the bottom of the pipe and collect in low places. Between these extremes are all those compounds usually known as gasoline or flashy gasoline. Dirt, sand, etc., are also often present.

The first problem in the transportation of this gas was to separate dust and dirt, and such liquids as water, oil, or gasoline. For this purpose drips or separators were provided in the lines from the wells to the main trunk line. These drips vary widely in design, but are all intended to catch and store the water and oil until the patrol man can blow the line out to the atmosphere. The simplest drip is a Tee with the opening down, and one or two joints of pipe connected on as storage for the liquid that accumulates. This serves fairly well for any liquid not held in suspension in the gas, but, of course, does nothing towards removing the suspended liquid. A great many attempts have been made to remove this suspended liquid, usually by a separator working on the centrifugal principle; but it is a very

difficult matter, indeed, to remove the last traces of liquid in this way, and, so far, efforts in this direction have only been partially successful. A new type of drip has recently been developed in California, but it has not as yet been fully tried out.

Any liquid not taken out by the field drips tends to collect in low sections of the line, and drips should be provided at all these low points. If pockets of liquid occur in the line, they cause the flow of gas to be pulsating instead of steady. This pulsating is difficult to overcome entirely, and is one of the chief sources of trouble in the operation of measuring stations.

Gasoline and oil are the main cause of rapid deterioration in the joints in the pipe lines, which are usually packed by rubber or composition rings. The oil and gasoline attack the rubber rings quite actively, and sooner or later cause leaks and blow-outs, especially as the pressure carried in the line is from 200 to 400 lb. per sq. in. Several substitutes for rubber are being used and seem to be more resistant; but the only way to eliminate trouble from this cause is to keep gasoline and oil out of the line.

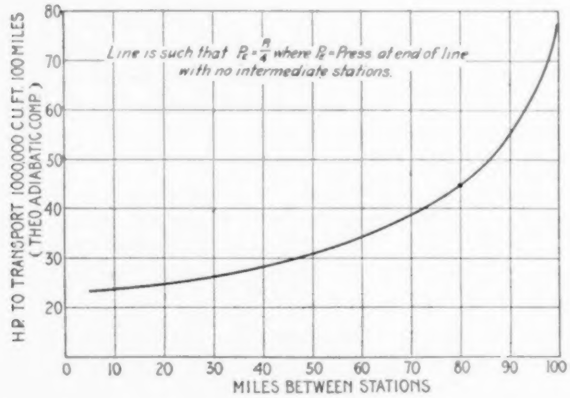

FIG. 1 CURVE INDICATING RELATION OF DISTANCE BETWEEN COMPRESSING STATIONS TO POWER REQUIRED

Gas entering the main trunk lines is often measured by orifice meters, and many points come up in connection with the practical use of these. In order to compute the amount of gas passing an orifice meter at any instant, it is necessary to know: *first,* the temperature of the gas; *second,* its gravity; *third,* the size and coefficient of orifice; *fourth,* the absolute pressure of the gas passing the orifice, and, *fifth,* the differential or drop of pressure in the gas in passing through the orifice.

The temperature is quite constant at any given time of year, and a mean temperature for the year is usually the contract basis on which gas passing a measuring station is computed and purchased.

The gravity of the gas is quite variable, even for gas coming from a given field; and when it is considered that gas passing a measuring station may come, in varying proportions, from several fields, the importance of making frequent determinations of the gravity of the gas passing a station to ensure accurate metering is evident. The gravity of gas varies in practice from 0.59 to 0.72, taking air as unity. It is determined by comparing the time for a given quantity of gas to flow through a small orifice with the time required for the same volume of air to pass the same orifice with the same head causing flow, and computing from the formula $G = \left(\frac{t_{gas}}{t_{air}}\right)^2$

So far as the writer is aware, nearly all gas companies, as well as companies manufacturing orifice meters, have been inclined to assume this gravity factor constant at 0.60 or 0.64. In all orifice meter measurements, as well as computations of line flow, or of Pitot tube measurements, corrections should be introduced for the gravity of the gas. In most of these computations the quantity will vary inversely as the square root of the gravity.

An idea of some of the problems incident to a compressing station may be obtained by a consideration of a typical compressing station of approximately 3000 h.p., which is capable of compressing about 40,000,000 cu. ft. of gas per 24 hours through 3 compressions and delivering it at 350 lb. gauge pressure. Up to this station the gas is transported by the natural field pressure. The prime function of the station is to re-compress the gas, which has dropped to a pressure too low for economical transportation, to a pressure high enough to deliver the requisite quantity through the remainder of the line to the points of consumption.

One of the chief problems is that of the condensation of gasoline in the line beyond the station. As the gas leaves the field, its pressure has been diminishing and its capacity for carrying gasoline as a vapor increasing. There is, therefore, little danger of deposit of gasoline in the line between the field and the compressing station. In this 40 miles of line practically all liquid has been removed by the drips along the line.

At the compressing station the pressure of the gas is raised to 300 lb. per sq. in. or higher, and its temperature raised to from 210 to 240 deg. fahr. After compression, the gas is passed through a cooler consisting of a large number of pipes in an open pond of water. Only occasionally is the temperature in the cooler low enough to condense out any great proportion of the vapors condensable at this pressure and line temperature. A separator is provided at the outlet of the cooler, but it can only take out vapors already condensed. It is, therefore, apparent that there is a possibility of further condensation of gasoline in the pipe line beyond the compressor station. This is exactly what occurs, and it causes a heavy depreciation in this part of the line. In one case, gasoline taken from a drip beyond this station was used in an automobile, and it was found that the exhaust smelled very strongly of burnt rubber. This would not ordinarily matter were it not for the fact that this same rubber has been dissolved out of the pipe joints, where it is very greatly needed.

From a theoretical standpoint it is entirely possible, by well-known processes, to condense and separate this gasoline before it enters the line. When it is considered, however, that there are 800 or 900 tons of gas passing this station per day, and that the gasoline content is very small, it is seen that the equipment necessary would involve a considerable investment, and the problem becomes a commercial one of whether or not the necessary equipment can be installed with an investment small enough to be profitable. This last problem will be special for each particular case, and is one which in most instances has not yet been solved.

Continuous accurate measuring of all gas into and out of the whole system is one of the perpetual problems of operation of any transportation company. In order to safeguard against loss due to the failure of any of the measuring apparatus, it is necessary to check up in all possible ways the quantities of gas passing meters. In some cases this can be done by line flow formulae, and in some by the displacement of compressing stations. It is found necessary and advisable to use both these methods wherever possible. The pipe line formula used is of the form $Q = K\sqrt{P_1^2 - P_2^2}$ where Q is the quantity of gas, and K is a constant depending on the length and diameter of the pipe line and the gravity and temperature of the gas. The formula for flow of gas through an orifice meter is of the form $Q = K^1\sqrt{hP}$ where K^1 is the constant of the orifice meter. In checking a meter by line flow formulae, the quantity involved is the same; therefore, by equating the two expressions and reducing, the expression $\left(\frac{K^1}{K}\right)^2 = \frac{P_1^2 - P_2^2}{hP}$ is derived. The ratio of the squares of the constants for any line and meter can be evaluated and is a constant. To check the meter against the line flow formula, it is then simply necessary to evaluate the expression $\frac{P_1^2 - P_2^2}{hP}$ and compare it with the constant derived as above. This check is so simple that meter station operators can easily make it and report the meter out of order, if the value figured is found greatly different from the constant.

It is well to point out here that if observed pressures are correct, the pipe line formula can never show an amount of gas passed less than the actual, but is apt to show a greater amount, due to excessive pressure drop from leakage or an obstruction in the line. The displacement of a compressor station gives a basis for comparison with the quantity of gas as shown by a measuring station which may show up defects in the operation of either. If the amount of gas measured would involve a volumetric efficiency of the compressors greater than 90 per cent, it is a very safe guess that the measuring station instruments are over-measuring the gas.

One very important function of a natural gas line is the equalization of the rate of production. The demand for gas in a city varies greatly from hour to hour of the day, being several times as great in the daytime as at night, and also varies greatly with atmospheric temperature. It would be a difficult matter to vary the output of a compressing station or a field at a distance from a town to meet the widely varying demand, if it were not for the equalizing effect of the transmission line. When the supply is greater than the demand, the gas is being stored in the line, and is available when the demand suddenly becomes much greater than the rate of supply. Often this equalizing effect will enable gas to be taken into the line at a uniform rate from the field for days at a time, while the demand at the other end of the line is fluctuating widely. The adjustment of supply to demand over the whole of a large system is an art in itself. It demands that all production shall be regulated from a central point by a dispatcher, who is in constant communication with all points of demand throughout the system.

Finally, regarding the problem of transporting gas by means of pipe lines and compressing stations, our gas fields are not only stores of latent energy in the form of fuel, but also stores of latent energy directly available as power in the highly compressed state of the gas. At present the pressure energy is used quite wastefully in the transportation of the gas itself. If, instead of allowing the pressure of the gas to drop to a third or a fourth of its initial value before re-compressing it, the pressure could be maintained at a high point, a great reduction in the total power required to transport the gas could be made. This would point to smaller compressing stations located at shorter intervals along the line. These stations would require less total power than stations at greater intervals performing the same service, and they could be simplified greatly by the omission of the after-cooler, as the smaller range of compression would not

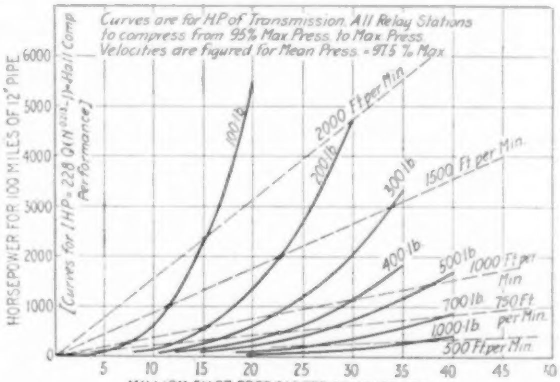

Fig. 2 Curves Showing Power Required for Transporting Gas at Different Pressures and Velocities

raise the temperature of the gas to an objectionable point. The curve, Fig. 1, shows the economy in power possible by more frequent stations operating through a smaller pressure range.

The curve in Fig. 2 has been prepared to show the relation between the amount of power required to transport different quantities of gas, the pressure at which the gas is transported and its linear velocity. In this case, the power is assumed to be applied at such frequent intervals along the line that the drop in pressure between the points of application of the power is only 5 per cent of the initial pressure. In other words, the pressure is maintained nearly constant, and the power applied represents the friction loss in the line at the pressure shown. It is seen that both the power required and the amount of gas vary directly with the linear velocity of the gas in the line. Also, that the power required to transport a given quantity of gas decreases very rapidly as the pressure at which it is transported increases, showing that there would be great economies possible if we could make our lines more perfect, so that higher pressures could be carried safely and without excessive leakage.

METAL SPRAY PROCESSES IN ENGINEERING AND ART

BY JOHN CALDER, BOSTON, MASS.

Member of the Society

ONE of the great metallurgical problems of the day has been to produce a non-corrosive surface on iron and steel, the indispensable but vulnerable materials of engineering construction, without affecting the physical properties of these metals or the shape or usefulness of the object treated. This has been attempted by chemical, electro-chemical, and mechanical methods. Tinning, galvanizing and sherardizing are the ordinary wet and dry chemical methods of applying a protective metal coating directly to a considerable volume of engineered and manufactured product but these processes are narrowly limited in the variety of their applications. In the other chemical processes the iron and steel surfaces have been deliberately attacked by chemicals to form from them stable, adherent compounds as a protective overlay which preserves the remainder of the object from corrosion. This is the general method of what are known as the " rust-proofing " processes.

Plating, the electro-chemical method, furnishes a continuous thin metallic web around iron or steel objects submitted

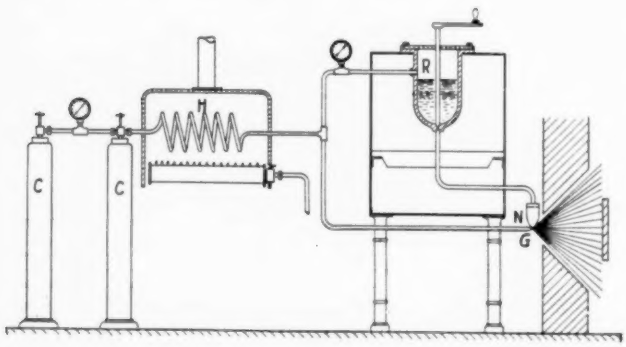

Fig. 1 Details of Apparatus Used for the Early Liquid Metal Spraying Process

to it, provided the shape and size of the article are suitable. It is necessarily limited to small objects. The adhesion of the plated coating is slight and its continuity is essential for service. The tinned or galvanized coating adheres, due to chemical affinity for clean iron, but its irregularity gives much trouble. The dry zinc galvanizing, known as sherardizing, gives a better result but is limited to the application of one metal under heat conditions, which confine it largely to black work and to objects the distortion of which is of no consequence.

None of the processes which have been briefly mentioned meet the general needs of the arts in a satisfactory way as they involve the exposure of engineered and manufactured products to injurious action from moisture, chemicals or heat. They admit of depositing only on metallic or metallized surfaces and they can apply but one or two metals out of the whole range of such elements and their alloys. They must ordinarily be applied to every part of the object and the deposits are not easy to control in the matter of location, quality and thickness. The permanence of the resulting adhesion is not assured and many of the coatings rapidly deteriorate.

There are demands in the arts for a method which will take the process to the work to be coated or to any part of it, and will secure the quick deposition on any coherent object, whether metallic or not, of any desired metal or alloy in any quantity, however minute. Inventors have labored over the problem for many years but commercial results have not been developed until recently because of the lack of economy in the earlier forms of apparatus, and even yet, the whole range of metals is not available. Effective pulverization of the very hardest metals still presents economic difficulties but lead, tin, zinc, aluminum, copper, nickel and their alloys can now be sprayed easily and these metals cover very well the practical range of protective coatings.

The overlaying of iron and steel for temporary effect with non-metallic substances such as paints, enamel, japan, and varnish has been the mechanical method necessarily followed hitherto for the great bulk of metal objects and structures and the renewal and maintenance of such protections involve enormous outlays. It is the object of this paper to describe the latest mechanical process, the Schoop process, for depositing electro-positive metals on iron and steel. Incidentally, the method permits the depositing of many other metals and alloys on coherent bodies whether metallic or not.

The process takes its name from M. U. Schoop, an engineer, of Zurich, who, in collaboration with other inventors, made the metal spray an effective coating agent. In the Schoop process, for which the United States patents have just been issued, the coating metal adheres to the object chiefly by mechanical union. The metal is discharged in hot impalpable particles moving with high velocity and these when directed upon a prepared object penetrate the pores of the latter while the spray is still plastic. The coating metal thus dovetails itself into the superficial pores of the object and does so in the presence of reducing gas which prevents oxidation at the junction of the metals.

The progress of invention on metal spraying has been chiefly directed toward making the metallic particles as small and as hot as possible, thereby avoiding oxidation, and reducing the pressure of air used and the cost of the gases employed. In 1902, Thurston was granted a patent (United States No. 706-701) for impacting, with unignited gas, metal in the form of dust upon a metallic base. His apparatus was not practical and no commercial results were obtained.

Within the past year, four United States patents have been issued which embrace all the important steps since Thurston's invention. Schoop invented (U. S. No. 1,128,058) a process for producing a fine spray from either molten or solid metal and also for producing separable metallic coat-

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ings or copies of the objects sprayed upon; this was known as the liquid metal spraying process. He later invented (U. S. No. 1,128,059) a process for projecting finely divided unmolten metal particles on to a surface, using an ignited gas and metal in the form of dust like Thurston; this was known as the metal dust spraying process.

Very soon afterwards Morf invented (U. S. No. 1,128,175) a process for melting, atomizing and projecting, practically simultaneously, solid metal and particularly metal in the form of wire; this was known as the metal wire spraying process. At the same time he also invented (U. S. No. 1,100,602) a successful apparatus (known as a "pistol") for effecting this process. These inventions above outlined form the basis

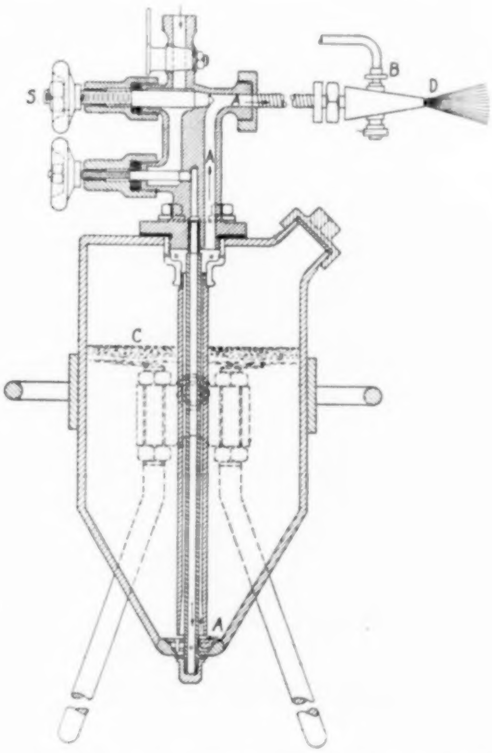

FIG. 2 PORTABLE APPARATUS FOR THE METAL DUST SPRAYING PROCESS

of the Schoop metal spray process as it is now operated in the United States.

The evolution of the apparatus has been interesting. The liquid metal process involved a large non-portable reservoir of hot metal weighing with the auxiliary parts over a ton; the metal dust apparatus weighed over a hundred pounds, while the "pistol" of today weighs less than four pounds. Figs. 1, 2 and 3 show the three forms through which the apparatus has passed.

In the apparatus represented by Fig. 1, a molten metal is allowed to run continuously from the reservoir *R* through a broad nozzle *N*, where it is broken up and swept away by a violent current of heated gas *G*, issuing under regulated pressure from containers *C* and reheated in its passage at *H*. The expansion of the gas chills the molten particles and forms a rapidly moving spray or fog of metal which impacts upon any object placed in its path and plates it.

Any metal fusible under the conditions of the apparatus can be used and owing to the low temperature of the fog, it is possible to plate very delicate and easily combustible objects, as well as metal articles. Aluminum plating, which could not be obtained by fusion or electrolysis on account of its ready oxidation, was easily obtained by this Schoop process.

The obvious objections to such an apparatus were lack of portability and the expense of melting and keeping fluid most of the metals in the unavoidable intervals of spraying. The result was that only the more fusible metals, lead and tin, were used where spraying on a continuous scale was possible and the liquid metal apparatus was never reduced to economical practice. It was observed with this apparatus, however, that the particles were not actually molten at the moment of impact and this suggested the next step.

Fig. 2 represents the second form of apparatus in which portability was secured and the metal particles to be sprayed were prepared in advance. Powdered metals in a very fine state of division have many of the characteristics of a liquid. Their fine particles mix with one another like drops,

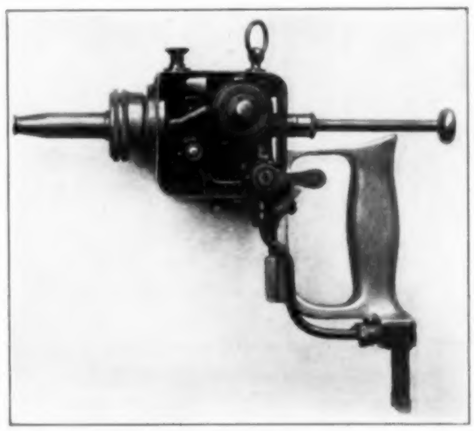

FIG. 3 EARLY FORM OF THE METAL SPRAYING "PISTOL"

they spread with facility and unite under the influence of very little force. The metal powder in the container *C* is entrained in an air blast *A*, heated in the flame of a blast pipe *B*, and projected with high velocity. The gas is burned at *D* and the supply of air is regulated at *S* to obtain complete combustion.

It was found that the anticipations from the use of the first apparatus were correct and that metal particles projected in a pasty condition produced plating as before. Most metal powders, however, tend to oxidize rapidly and the use of this apparatus was practically restricted to tin and zinc on this account. Even with tin, the expense of metallic powder was prohibitive, but the plating with tin and zinc was very good. In the case of zinc, the apparatus known as the cyclone is still the most economical instrument for plating large surfaces with that particular protective metal. Zinc dust is a by-product in the stacks of zinc smelteries. With the Cyclone apparatus, it can be impacted on steel structures either in the field or at the factory.

Inventors then set themselves to overcome both the chemical and economic difficulties, viz.: to dispense with mass melting and dust preparation and to secure instant and simultaneous operation of melting and pulverization, and control with a handy, economical and easily transportable

appliance. The result was the ingenious instrument known as the "pistol" which is shown in Fig. 3.

The principle involved consists, as shown in Fig. 4, in feeding a fine wire *W* of any metal into a reducing flame zone *Z* at such a constant speed that the position of the end of the wire *E* remains stationary, the melting rate being exactly equal to the rate of feed. Under such conditions the wire end melts a drop at a time and each drop at the instant of formation is struck a violent blow by an air blast *A*. In other words, the pistol is a machine gun which automatically manufactures its ammunition from a reel of wire and bombards the object to be plated with plastic projectiles of extremely small size.

The resulting fog or spray of fine metallic particles into which the drops are divided takes the form of a diverging cone *C* with a core of reducing gas *G* in which the particles are entrained, and a surrounding sheath of air *A* which is rapidly expanding and cooling. Any suitably prepared object placed in the path of this metallic spray is plated through impact without undue elevation of temperature.

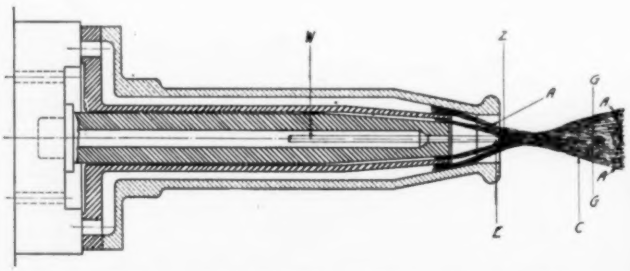

FIG. 4 DIAGRAM ILLUSTRATING APPLICATION OF REDUCING FLAME TO METAL WIRE IN THE PISTOL

Fig. 6 shows a section of the commercial spraying pistol now in use. The principal parts of the pistol consist of an outer casing *A*, cast of aluminum, with a central projecting tube forming a handle, a wire feed mechanism mounted entirely upon the cover *B* of the turbine chamber, the turbine *C* actuating the wire feed mechanism, gas, air and wire nozzles mounted upon the outer casing held in position by a hand nut *D*, and a removable cover *E* which completes the enclosure of the outer casing.

Gas and air ducts are drilled in the outer casing. The flow is controlled by the tapered valve *F* provided with a handle *G*. The wire feed mechanism is actuated by a turbine *C* mounted on a vertical shaft running in ball bearings; a worm is cut in the upper end of the vertical shaft and drives by worm wheels the horizontal shafts *N* and *O*, Fig. 6, which are provided with worms in turn driving the worm wheels *P* and *Q*.

The wheels *P* and *Q*, Fig. 6, are provided with slots to engage the projecting lugs of the lower feed wheel *R*. The upper feed wheel *S* mounted in the pivoted frame *T* is provided with shrouds controlling the position of the lower feed wheel *R*. The lower feed wheel can be engaged in either worm *P* or *Q* by raising a clip *I*, shifting laterally in either direction and locked in by the opposite clip. The shift can be readily made by allowing the mechanism to run slowly by a slight opening of the starting valve.

Pressure is applied to the feed wheels through the pivoted frame *T* by a coiled spring, and controlled by the operator by means of the release lever *K*. The final adjustment of the wire feed is controlled by the needle valve *M*, Fig. 6. The turbine and shaft complete is assembled in the outer case and properly adjusted independently of the other mechanism.

The wire feed is entirely assembled on the turbine cover *D* and, when properly adjusted, is secured in position. The wire nozzle base *U* provides an adjustment for position of wire and gas nozzles, and is secured in position by a headless set screw. The upper end of the stem of the turbine cover is provided with an annular groove, which is engaged by the spring loop *V* and secures the removable cover *E* of the case. Loop *V* provides also a means for hanging the pistol on a conveniently located hook.

The operation of the pistol is as follows: The gas and blast nozzle faces *B* and *C* are securely clamped to form gas tight joints by tightening the hand nut *D*. The end of the central or wire nozzle is then 0.015 in. inside the gas nozzle and the stationary melting point of the wire is 0.03 in. inside the air blast nozzle. The wire diameter used is from 0.0319 to 0.0375 in., except for lead and tin which are used in larger sizes owing to their rapidity of melting.

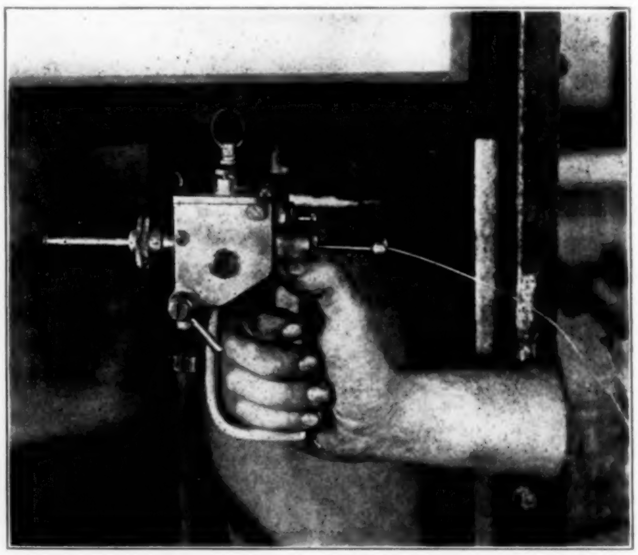

FIG. 5 VIEW OF A COMMERCIAL SPRAYING PISTOL IN HAND READY FOR USE

The feed gears having been set in mesh at the approximate speed required for the wire selected, the air alone is turned on and the speed tested with a short length of wire. Adjustment, if necessary, is made by the needle valve which modifies the speed 2 ft. per minute plus or minus.

The end of the wire reel is then threaded through the stock receiving tube, between the gripping feed rolls and into the central wire nozzle and the fuel gas pressures from the containers are adjusted by the reducing valves and gauges thereon to the tabular requirements for the metal to be sprayed. The pressures of the fuel gases seldom rise above one atmosphere and hydrogen or Blau gas are the reducing gases usually employed. This gas is now admitted by slightly opening the starting valve and when ignited with a match burns quietly as a pilot light.

The starting valve is then opened up full and oxygen is admitted gradually until the flame zone is established. All back-firing is avoided by keeping the reducing gas always in excess of the oxygen, the ratio being three or four to one. The above movements are made in rapid succession on a

light instrument which can be held in one hand and the spray is started up the moment the constant melting position of the wire is reached.

The spray so established is essentially a metal plating airbrush, the diameter of which 5 in. from the pistol end is about 2 in. Objects to be plated are operated upon by pointing the pistol normally to the surface to be coated at any moment at about 5 in. distance and traversing the pistol across the surface with a regular motion. A single coating is about 0.001 in. thick. The operator's vision easily guides him in distinguishing between the coated and uncoated portions and also between a first and second coat.

Two thousandths of an inch well impacted upon a surface are just as effective as a much greater thickness and of course unnecessary sprayed metal increases the cost, as the latter is directly proportional to the thickness. Not only on the score of economy but also to preserve toughness the coating should be of minimum thickness for the anvil action of the metallic spray on a solid metal object is lost above a few thousandths of an inch thickness and a process of cold working follows which produces a brittle scale readily detachable. In practice this matter is easily regulated.

Fig. 5 shows the pistol held in the hand ready for action with the wire thread in position. Fig. 7 shows the pistol applied to coat a wooden pattern for protection with lead, and in Fig. 8 a cement statuette is being covered with bronze.

Gas bombs with fittings and air at 40 lb. pressure are the only requisites besides the pistol and its hose connections for plating non-metallic objects such as wood, stone, paper, cement, cloth, etc. All metallic surfaces should have the scale cleaned off and their pores opened by preliminary sand-blasting.

It will be seen from Table 2 that 0.001 in. thickness, one square foot in area, can be sprayed with the common metals for a small sum. The total cost for German silver is $3\frac{1}{2}$ cents, for copper, 3 cents, for tin, 5 cents, for brass, $2\frac{3}{4}$ cents, for zinc, 2 cents, for aluminum, $1\frac{3}{4}$ cents and for lead $1\frac{1}{2}$ cents per square foot.

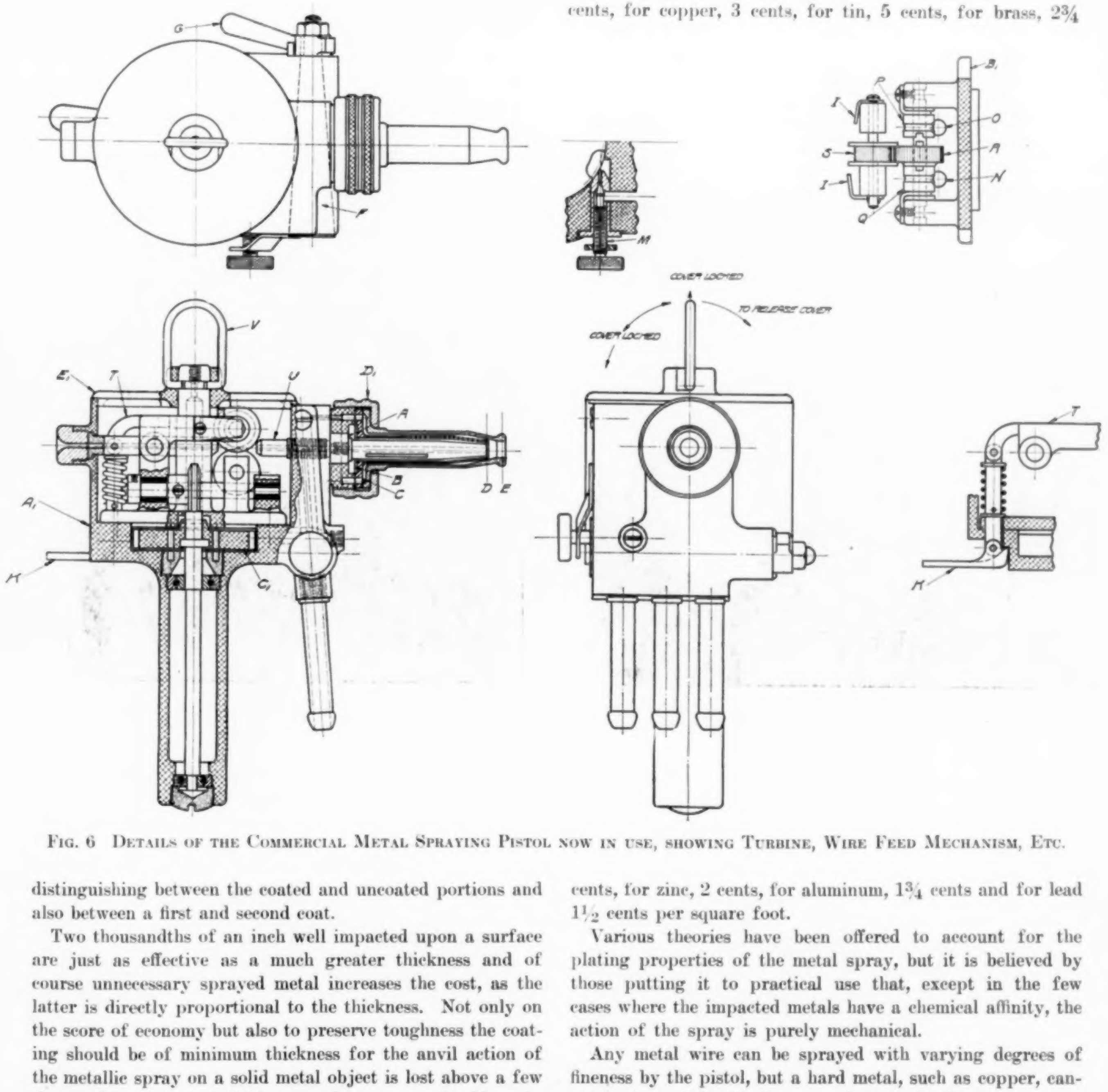

FIG. 6 DETAILS OF THE COMMERCIAL METAL SPRAYING PISTOL NOW IN USE, SHOWING TURBINE, WIRE FEED MECHANISM, ETC.

Various theories have been offered to account for the plating properties of the metal spray, but it is believed by those putting it to practical use that, except in the few cases where the impacted metals have a chemical affinity, the action of the spray is purely mechanical.

Any metal wire can be sprayed with varying degrees of fineness by the pistol, but a hard metal, such as copper, cannot be impacted with the same degree of adherence upon a solid copper object as it would be upon a more porous cast iron object or upon one of the soft metals such as lead or zinc. The coatings may be ground, polished and buffed like any ordinary metals, but polished sprayings do not offer

themselves as economical substitutes for cheaper and less adherent platings which are deposited in smooth condition.

As metal spraying is essentially a kinetic energy process the degree of adherence obtained in any instance depends upon the relative hardness and porosity of the sprayed metal and its base. For some decorative purposes this is of no consequence, but where stress, wear and chemical action are involved it is quite important to choose the appropriate coating.

In spraying where the softer metal forms the object, the body of it, as well as its superficial pores, will be penetrated by the harder metal with its projectile action. When the condition is reversed the softer spraying metal will fill the open pores of the harder object and key itself into the former in cooling off, but it will not penetrate the solid parts of the body. In either case, however, with proper preparation of clean open surfaces a durable adherent coating is obtainable.

FIG. 7 VIEW OF THE PISTOL AS USED FOR COATING WOODEN PATTERN WITH LEAD

The applications of the process already made are numerous and new ones are being suggested continuously. In this connection it should be noted that, though coatings of all the commercial metals and of their alloys can be made on any other metal, and on almost any coherent object, except articles containing grease, the choice of a metal coating should be conditioned by the service which it has to render.

Spraying a metal so that it plates an object gives the coating metal no chemical properties it did not possess before. Hence sprayed coatings used for protective purposes, rather than for finish or decoration, are restricted for resisting acids to lead, for resisting air, moisture, sea water, and ordinary atmospheric action to lead, tin, zinc and aluminum, and where superficial oxidation of the coating is of no importance copper and its various alloys can be freely used also.

In general the applications of the process may be divided in five groups, viz: protective coatings; bonding or junction coatings; electrical coatings; decorative coatings; detachable coatings. It is with the first three of these that the engineer is chiefly concerned.

Protective coatings on steel or iron may be either original coatings of the whole of an object or any part of it or local applications with the pistol to repair damage or wear of a coating made by another process. The repair of the troublesome defects on galvanized sheets is an example. The localization of copper deposits on iron aand steel for the purpose of the cementation process and for controlling hardening is easily and quickly accomplished by the pistol. The results are reported to be much better than those obtained from the necessarily irregular and soft electrolytic deposits, the area of which cannot be absolutely controlled.

Many engineering structures used in the arts, such as steel and iron tanks, girders and machinery of all descriptions, are subject to the action of liquids and chemicals and corrode rapidly, particularly at joints. It is not possible to plate such structures by any other coating method. In such cases a metal is selected which will resist the corroding agent and

FIG. 8 APPLICATION OF THE PISTOL IN COATING A CEMENT STATUETTE WITH BRONZE

is sprayed in the form of wire on all the seams and joints, these having previously been cleaned by sand-blasting.

In many cases the treatment of the joints is sufficient, the solid metal resisting oils and liquors for a long time when the seams are rendered free from attack. Railroad and bridge girders can be handled by portable outfits to protect them from the atmosphere and moisture. This is a large industrial field of application in which lead, tin, and zinc sprayings are used, and proper initial treatment of this kind or in the field during erection dispenses with all need for repeated painting.

Laundry machinery, dairy appliances, water heaters, and similar structures exposed to moisture and chemicals can be protected against corrosion due to electrolysis in many cases by sprayed deposits of zinc suitably located, or may be wholly tinned or galvanized by the Schoop process.

Bonding or junction coatings can be freely applied to brick, metal or porcelain connections with the metal spray. The porosity of stone, both natural and artificial, lends itself readily to this use. The refractory hearths of furnaces using

TABLE 1 DETAILS OF THE COST OF USING METAL SPRAYING PISTOL ONE HOUR

Metal	Diameter, Inches	Speed of Wire in Feet per Min.	Pounds per Hour	Oxygen			Blau Gas			Labor per Hour	Cost of Air per Hour	Cost of Spraying	Wire Cost per Hour	Total Cost per Hour	Total Cost per Minute
				Gauge Pressure	Cubic Feet	Cost at \$.02 Cu. Ft.	Gauge Pressure	Cubic Feet	Cost at \$.008 Cu. Ft.						
Copper	.032	12	2.15	27	24	\$.48	25	13	\$.104	.30	\$.20	\$1.08	\$.366	\$1.446	\$.0241
Brass	.032	12	2.15	28	21	.42	26	14	.11	.30	.20	1.03	.335	1.365	.0228
Bronze	.032	12	2.15	27	24	.48	25	14.5	.116	.30	.20	1.09	.432	1.522	.0253
German Silver	.032	12	2.15	28	23	.46	26	14	.11	.30	.20	1.08	.545	1.625	.0271
Aluminum	.0375	16	12	19	36	.72	16	13	.104	.30	.20	.32	.44	.76	.0127
Zinc	.0375	18	4.3	15	20	.40	13.5	10	.08	.30	.20	.98	1.23	2.21	.0368
Lead	.076	25	30	14	20	.40	12	8	.064	.30	.20	.964	3.00	3.964	.0661
Tin	.061	25	15	13	24	.48	14	10	.08	.30	.20	1.06	10.50	11.56	.1933

the surface combustion principle are readily bonded by the Schoop pistol to their porcelain or metal gas-conducting tubes by spraying the assembled parts with a metal of sufficiently high fusing point. Ordinary solders are of no service in furnaces depending upon radiant energy and the refractory cements and mortars will not stand the necessary stresses and wear.

This is a single instance of the possibilities in bonding non-metallic surfaces. Though the pistol coatings are amorphous and vitreous throughout and are not calculated to carry the stresses of ordinary metal parts there are many static uses of metal in which the Schoop coating is useful. The electric appliance field is one of these. Carbon in all its resistance forms can be freely sprayed with copper and that metal can be applied in minimum quantity to any piece or portion of a piece of apparatus.

The most recent electrical application is the construction of condensers, especially for wireless service. The Schoop pistol will spray an adherent coat of copper on ordinary sand-blasted window glass. Two-thousandths of an inch is sufficient to produce a highly efficient and cheap plate much superior to rolled tin foil coverings or galvanic deposits of copper on glass. Lead sprayed on glass also furnishes a very cheap and effective condenser plate.

The decorative coatings are of less interest to engineers, but the field is large and, apart from the coating of baser metals with the bronzes and other alloys, almost any metal can be sprayed freely on naturally porous substances such as wood, paper, cloth, stone, cement, etc., and sprayed coatings can either be polished, treated with chemicals to form various patina effects, or allowed to form a natural patina, thus securing protection of the material from atmospheric action.

The detachable coatings form an interesting study and have yet to be developed for many of the arts. In all the applications already described the object has been to obtain an *adherent* coating of any selected metal upon a clean sand-blasted metallic surface or upon a clean surface of a naturally porous non-metallic object.

It has been found that if the Schoop spray be turned upon a smooth greased surface of reasonable hardness, the bombarding fog of metal particles will remain upon the surface without impacting and will copy the surface to its finest line or detail. On cooling and tapping this reverse it detaches readily and by using it as a mold and repeating the treatment with a film of grease, a detachable copy of the original object, a coin, medal or any relief subject can be obtained in any desired metal.

The application of these detachable coatings to the printing plate, dental plate and other processes in the arts requiring rapid and accurate reproduction is now under development. It is obvious that copper and bronze of a crystalline hard character would give much greater service than the short-lived plates now used of soft electrolytic copper.

The various possibilities of the spray so far developed are indicated by the samples of its work exhibited and by the demonstrations of the pistol in actual operation. Tables 1 to 3 show the data of gas consumption and total cost of spraying a square foot 0.001 in. thick of some of the commoner metals by means of the Schoop pistol; also, the cost of spraying per pound and by the hour and the rate of deposition.

TABLE 2 COST TO COVER ONE SQUARE FOOT BY SPRAYING

Metal	Diameter, Inches	Speed of Wire per Minute	Time to Cover One Square Foot		Thickness, Inches	Cost of Spraying	Cost of Wire	Total Cost
			Min.	Sec.				
Copper	.032	12	1	10	.001	\$.021	\$.0076	\$.0286
Brass	.032	12	1	10	.001	.020	.0071	.0271
Bronze	.032	12	1	10	.001	.024	.0101	.0341
German Silver	.032	12	1	10	.0089	.024	.0105	.0345
Aluminum	..	16	..	40	.001	.0128	.0042	.0170
Zinc	..	18	..	30	.0015	.0081	.0115	.0196
Lead	.076	25	..	25	.002	.0064	.021	.0274
Tin	.062	25	..	30	.002	.0088	.0875	.0963

TABLE 3 COST OF SPRAYING ONE POUND

Metal	Feet per Pound	Speed of Wire in Feet per Min.	Time to Spray One Lb.	Cost of Spraying	Cost of Wire	Total Cost
			Min.			
Copper	340	12	28	\$.50	\$.1725	\$.6725
Brass	350	12	28	.47	.1625	.6325
Bronze	344	12	28	.53	.2225	.7525
German Silver	330	12	28	.51	.25	.76
Aluminum	761	16	48	1.075	.37	1.445
Zinc	283	18	14	2.27	.33	2.60
Lead	50	25	2	.032	.10	.132
Tin	105	25	4	.07	.70	.77

THE ELECTRIC LOCOMOTIVE

BY A. H. ARMSTRONG,[1] SCHENECTADY, N. Y.

Non-Member

THE meeting of the local section of the Society in Chicago held on May 14, 1915, was devoted to the subject of The Electric Locomotive as applied to steam railroad conditions. Addresses were presented by A. F. Batchelder and A. H. Armstrong of the General Electric Company, Schenectady, N. Y., the first speaker discussing the development of heavy electric traction from the historical Baltimore & Ohio tunnel locomotives installed in 1895 to the most recent applications in the Butte, Anaconda & Pacific and the Chicago, Milwaukee & St. Paul electrifications; Mr. Batchelder's remarks were in the nature of an informal talk illustrated by numerous lantern slides. Mr. Armstrong supplemented the first speaker's descriptive talk with interesting comparisons with the steam locomotive as to the selection and rating and his remarks are presented herewith.

The first 47 New York Central locomotives of the S type represent a distinctive type admirably adapted to high speed passenger service. This type is designed to deliver a moderate tractive effort at a high speed, giving a tractive effort of 7,100 lb. continuously at a speed of 56 miles per hour and a one hour rating of 20,600 lb. The driving motors, four in number, are thus able to give an output of 2,200 h.p. for a period of one hour without overheating. The later T type of locomotive, weighing approximately 130 tons, has a capacity of 14,000 lb. tractive effort at a speed of 53½ miles per hour or a continuous capacity of approximately 2,000 h.p. output of the motors. For the one hour period, the output is 2,600 h.p.

The reference to continuous and one hour capacities and also to starting tractive effort may demand the explanation to the steam railroad man that the time element plays a very important part in the determination of the rating of an electric motor. In a steam locomotive, the tractive effort or pulling power is determined by the diameter of the piston and the steam pressure behind it, and the locomotive can deliver this tractive effort continuously provided it has sufficient boiler capacity to supply the quantity of steam demanded and the fireman is sufficiently industrious to keep covered the grate which is supposed to have sufficient surface. With the electric locomotive on the contrary, allowance must be made for the fact that the insulation used deteriorates if heated continuously above a certain amount. It takes a considerable time for the motor to heat up to this dangerous point, thus giving rise to a momentary rating or starting effort, a one hour rating and a continuous rating, the latter being the output which the motors can give continuously without injurious heating. In other words, the steam locomotive engineer is concerned in keeping his boiler hot, while the effort of the designer of electric locomotives is to keep his machine cool.

In the early electric locomotive design there was no such thing as continuous rating. The service which it was called upon to perform was of an intermittent character, the runs between stops were short and the designing engineers were concerned mostly with the question of starting or accelerating, tractive effort and commutation. Therefore, the continuous rating of the early motors had no place in considering its design. With the extension of electrified lines and more especially with the introduction of the electric locomotive on main steam trunk lines, it was found that the motive power was called upon to deliver a continuous output for long periods at a time, and it became necessary to introduce air-blown or ventilated motors as well as fire proof insulation in order to secure the large output required without exceeding the limitations of space and weight imposed by standard gauge and reasonable diameter of wheels, wheel base and weight per driving wheel. We are therefore designing electric locomotives to-day suitable for the heaviest class of freight and passenger service. Such locomotives are entering into competition with the steam locomotive with a full appreciation of the phenomenal growth and possibilities of the latter as developed during the past few years, as well as a knowledge of the growth in the demands placed upon the motive power to take care of modern high speed passenger and freight train service.

In designing such electric locomotives, the electrical engineer is fully alive to the fact that a steam locomotive has been built weighing 750,000 lb. on drivers and having a total weight of 850,000 lb., and that nearly 90 per cent of the total weight of locomotive and tender is now rendered available for tractive purposes by the development of the Mallet principle to include cylinders placed upon the tender itself. It is also known that the tractive effort of these locomotives has increased from the 40,000 lb., of the early consolidation engines weighing 200,000 lb. on the drivers, to values as high as 160,000 lb. for the latest type of Mallet. It is also known that the introduction of the steel passenger car, together with the need of high sustained speeds of between 60 and 70 miles per hour, call for the hauling of passenger trains weighing over 1,000 tons and provision is made in the latest New York Central electric locomotive to take care of 1,200 tons at 60 miles an hour. Due appreciation is also paid to the results secured with the combination of superheating and simple engine which has so largely replaced the compound. Also the increased capacity afforded with the use of mechanical pushers and fire door openings with hand firing has increased the efficiency of the fireman so that it is now possible for him to throw between 5,000 and 6,000 lb. of coal per hour where previously 4,000 lb. might be considered good performance. Finally it is fully understood that the modern steam locomotive has been so improved as to fuel economy by the introduction of superheating, fire arch and other developments that it is possible to get an indicated horse-power with the expenditure of 15 lb. of steam and less than 2 lb. of coal under the best conditions of operation, and that with the use of mechanical stokers or with oil fired boilers, locomotives are in operation giving 3,000 i.h.p. or more.

Fully appreciating the above facts and the magnitude of

[1] Assistant Engineer, Railway and Traction Department, General Electric Company.

Account of meeting of the Chicago local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on May 14, 1915.

the problem confronting him, the electric railway engineer nevertheless offers in the modern electric locomotive a type of motive power which can accomplish results in transportation which are not possible to obtain with the steam locomotive both as regards tonnage handled, speed on mountain grades and general flexibility and economy in operation. The first large electric locomotive built was placed in operation on the Baltimore & Ohio Railroad in 1895, and it is worthy of note that this was a gearless locomotive and a forerunner of the highly efficient gearless locomotives now in operation upon the New York Central Railroad to-day. The New York Central locomotive, as developed in the later T type, is capable of hauling the heaviest overland passenger trains over any length of track that may be electrically equipped, and with-all at a cost for upkeep, including all labor and material spent in maintenance, of not exceeding $3\frac{1}{2}$ cents per mile run, as is shown by the records of the New York Central during the operation of the past seven years.

The first railroad in this country to adopt electric freight locomotives having large sustained output capacity was the Butte, Anaconda & Pacific Railway. Some three years ago the construction of 92 miles of the total of 114 miles of track was commenced, being completed for freight operation in May, 1913, and for complete freight and passenger operation in October, 1913. There are still four or five steam engines in operation on Butte Hill, but these will be replaced in the near future, so that in a short time the entire road, or 114 miles of track, will be in operation electrically. The one motive inspiring this installation was economy in operation, and preliminary reports indicated that the savings in electric over steam operation should be sufficient to pay something like $17\frac{1}{2}$ per cent upon the capital required to electrify. During the first six months operation of this road, careful detail figures were kept on the cost of electric operation, every item of expense being accounted for, with the result that, prorated over the entire fiscal year, there was a saving shown of $240,000 over the cost of steam operation during the previous year with practically the same tonnage handled. The entire first cost of this installation, including all material and labor and contingent expenses as well as interest on money during construction, was approximately $1,200,000, so that the saving above indicated results in a 20 per cent gross return upon the capital required for electrification. This makes no allowance for the scrap value of more than 20 steam locomotives discarded.

On this road, the heaviest class of freight trains are operated electrically, regular operation calling for the movement of from 3,500 to 4,000 tons behind the locomotives from the Butte Yards to Anaconda, and record has been made of train weights as high as 4,500 tons trailing against a gradient of 0.3 per cent. Each locomotive (Fig. 1) weighs 80 tons, all on drivers, and two such units are coupled together, operated by one engineer and comprise a complete locomotive hauling the above tonnage. At the Butte end, there is a gradient of $2\frac{1}{2}$ per cent against the returning empty cars, and at Anaconda 1.1 per cent grade against which one of the above locomotives hauls 25 cars or approximately 2,000 tons.

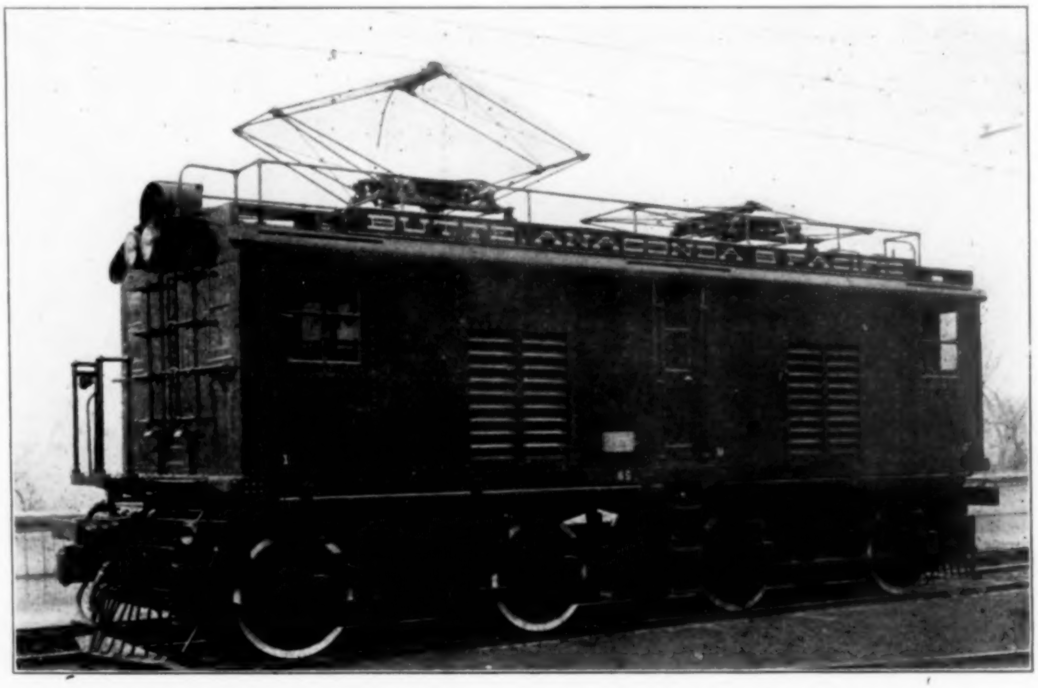

Fig. 1 The 80-Ton Locomotive Unit of the Butte, Anaconda & Pacific Railway

This leads up to the subject of the rating of an electric locomotive. The Butte locomotive (Fig. 1), weighing 80 tons, all on drivers, will give a continuous tractive effort of 26,000 lb. at a speed of approximately $16\frac{1}{2}$ miles per hour at full substation line voltage; this corresponds to $16\frac{1}{4}$ per cent of the weight upon the drivers. Investigation of the locomotive loading regulations on many steam roads operating over ruling grades indicates that it is almost universal practice to assign to a locomotive a trailing load so that the tractive effort at the rim of the drivers, as required on ruling grade, will be equivalent to approximately 18 to 19 per cent of the weight upon the drivers. In other words, from 18 to 19 per cent coefficient of adhesion between driver and rail is now considered good steam practice, and the electric locomotive

rating is closely following this same steam practice. The electric motor, of course, gives a perfectly uniform rotation to the driving wheels, and should thus give something like 10 per cent more tractive effort than the steam locomotive with its reciprocating parts. Continued operation will develop whether this additional 10 per cent tractive effort can be utilized or not. In the meantime, steam practice is being followed in the loading of electric locomotives.

In adopting a coefficient of adhesion of 18 or 19 per cent as the basis of determining the tractive effort required on ruling grades, it is evident that there is left for starting purposes the difference between the above coefficient of adhesion and the slipping point of the wheels, whatever that may be, as determined by the condition of the track. Tests on electric locomotives have shown a coefficient of adhesion as high as 35 per cent, or even more under specially favorable conditions, but it is fair to assume a maximum of 30 per cent as available in operation and even 25 per cent may be nearer the average. There is therefore, not much difference between the tractive effort required on ruling grades and that required for starting, and in order to be "fool proof" and capable of meeting the exacting demands of the heaviest kind of service, the electric locomotive should be capable of delivering continuously a tractive effort equal to from 16 to 18 per cent coefficient of adhesion of the weight upon its drivers. The Butte locomotive is therefore rated at 26,000 lb. or 16.25 coefficient of adhesion as its continuous output, and this capacity is sufficient to meet all demands of operation on the Butte, Anaconda & Pacific Railway.

Coming now to the latest type of trunk line electric locomotive, the one designed by the General Electric Company for the Chicago, Milwaukee & St. Paul Railway (Fig. 2) is direct development of the Butte, Anaconda & Pacific both as to type of locomotive and general system of electrification installed. The weight of the locomotive is 260 tons, of which 400,000 lb. are on the drivers. Each of the eight driving motors has a continuous rating of approximately 375 h.p., making the sustained continuous output of the complete locomotive, 3,000 h.p. at the rim of the drivers. This locomotive, however, will give a considerably larger output for short periods. For example, it has a capacity of 3,440 h.p. for one hour and even greater than this for short periods. The sustained tractive effort is 72,000 lb. at a speed of 15¾ miles per hour at full substation line potential.

Compare this electric locomotive with the Mallet engine of approximately the same weight now in operation on the St. Paul road, as shown in Fig. 3, and we find that the Mallet engine has 76,200 lb. tractive effort corresponding to 23.5 per cent coefficient of adhesion, but those of you familiar with the performance of this particular engine know that it toils painfully at speeds seldom exceeding 7 to 10 miles per hour when operating at its full hauling capacity. It is in this matter of higher speed for the same tractive power that the electric locomotive excels. In fact the question of speed is simply one of cost and expediency, as the horse-power output of the electric locomotive can be raised to any value desired without exceeding the limits of track loading.

FIG. 2 THE DOUBLE UNIT 260-TON LOCOMOTIVE OF THE CHICAGO, MILWAUKEE & ST. PAUL RY.

The St. Paul locomotive, weighing 260 tons, has capacity to haul a 2,500 ton trailing load behind the locomotive on a 1.0 per cent grade at nearly 16 miles per hour without any assisting locomotive. The St. Paul road in Montana and Idaho crosses three mountain ranges, the Belt Mountains, the Rocky Mountains and the Bitter Root Mountains. From Lombard to Summit, in the Belt Mountains, a distance of 49 miles, there is an average gradient of 0.71 per cent and a ruling grade of 1 per cent against which one locomotive will haul a trailing load of 2,500 tons without assistance. Between Pidemont and Donald, a distance of 22 miles to the summit of the Rocky Mountains, there exists a 2 per cent grade against which two locomotives will haul 2,500 tons trailing, the second locomotive being used at the rear of the train as a pusher. A second pusher division exists in crossing the Bitter Root Mountains of Idaho, making only two

pusher divisions in the 440 miles of electrified road from Avery, Idaho, to Harlowton, Montana.

The general design of the St. Paul locomotive, as shown in Fig. 3, comprises a locomotive divided in halves for facility in shop repairs, each half being identical and equipped with four driving axles and two guiding axles. The design is identical with the Butte locomotive except for the addition of the four-wheel guiding truck at each end of the locomotive. One of the reasons for the introduction of the truck is that the same locomotive is thus made available for both passenger and freight service. This does not mean that any locomotive can be used interchangeably at will in both freight and passenger service, but it does mean that all parts of the locomotive are identical whether used for freight or passenger with the single exception of the gearing between motors and driving axles which has a ratio of 4.56 for

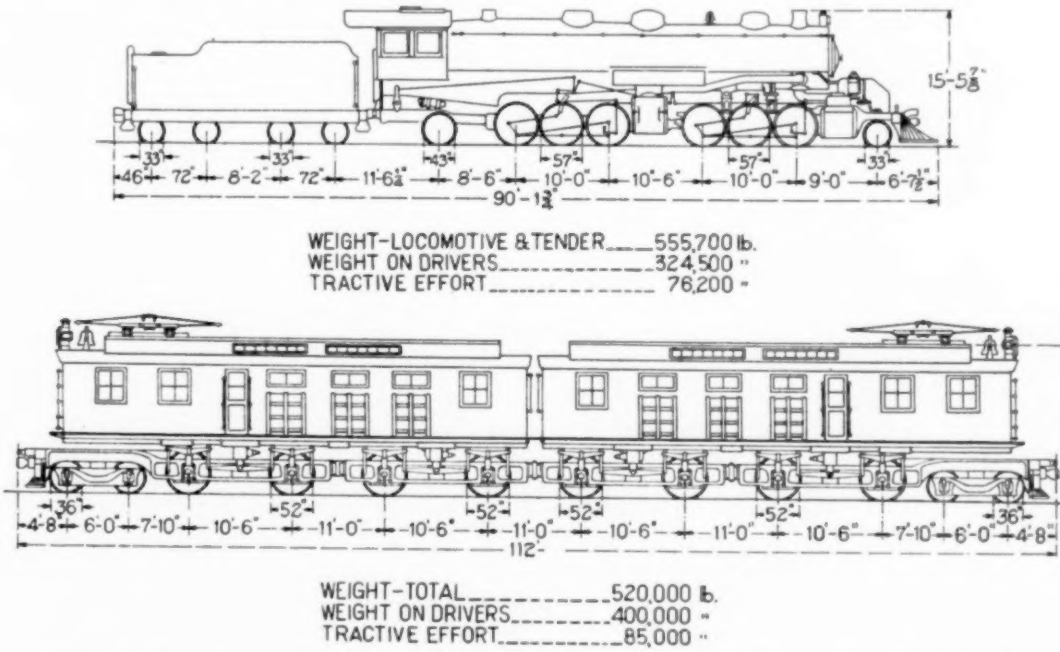

FIG. 3 COMPARATIVE DATA ON THE ST. PAUL MALLET STEAM AND DOUBLE UNIT ELECTRIC LOCOMOTIVES

freight service and 2.45 for passenger service. This adoption of a uniform type of motive power for all classes of service should result in affecting a great reduction in the cost of maintaining the locomotives of the four engine divisions electrified.

A second type of light locomotive for shifting service may be introduced later, although in this connection arrangements are being made to operate independently one-half of the through locomotive by equipping it with draft gear in place of the articulated joint joining the two halves. This will provide a locomotive weighing 130 tons having 200,000 lb. on the drivers and capable of doing one-half the work stated above as the capacity of the combined locomotive, this half locomotive requiring turning if used in passenger service, as it has guiding axles at one end only.

The installation on the St. Paul road will use for the first time on such a large scale a principle which should be of the greatest advantage in the operation of mountain grade divisions, that is, the utilization of the motors on the locomotives to brake the train on down grade and return the energy of the descending train back into the line. The efficiency of the locomotive, both electrical and mechanical, is nearly 90 per cent maximum, not taking into account the minor losses in driving ventilating fans and air compressors. When descending heavy grades, therefore, the reversible feature of the locomotive, permitting it to transform mechanical power received into electrical energy, suggests by this means a considerable reduction in the amount of power required to operate the road. It is probable, however, that a power saving of less than 10 per cent will result from the regenerative braking feature of the electric locomotives, and the principal advantage resulting from the introduction of the electric brakes will be to relieve brake shoes and wheels from the dangers attending overheating. To those of you who are familiar with the handling of trains on long and heavy down grades this argument will appeal in full force, as it is not an uncommon sight to see brake shoes red hot as a result of sustained application on down grades of long extent.

In regard to the suitability of the New York Central gearless type of locomotive for passenger service, it has been pointed out the entire absence of mechanical losses in the motor other than the brush friction on the commutator, but the facts are so important as to bear repetition. There are no bearings on the motor of any kind as the armature is mounted directly upon the driving axle and the field structure is part of the frame which is carried upon the journals. The electrical efficiency of the motor and the frictional losses on the commutator due to the brushes are therefore the only losses to be considered, and the efficiency of this locomotive in operation is therefore between 93 and 94 per cent. In other words, of the electrical input received at the third rail shoes, from 93 to 94 per cent appears as useful mechanical output at the rim of the drivers. This in itself is a most remarkable performance, but the value of this high efficiency locomotive is rendered more important when it is explained that the maximum efficiency occurs at approximately the free running speed between 50 and 60

miles per hour. In other words, the motor has a drooping efficiency curve, being highest at free running and lowest at overloads or during acceleration, and in this respect being just the reverse of the efficiency curve of geared motors which reach their highest point at practically the one hour load capacity of the motors. The gearless locomotive is therefore particularly adapted to operate on fairly level profiles and could not be utilized to such great advantage on roads like the St. Paul which contains many heavy grades sustained over long extent. It is very difficult to combine in one structure motors capable of hauling 800 tons trailing over heavy sustained grades, and also have the chaaracteristics required for good operation on level track at 60 miles per hour, and in the St. Paul locomotives recourse to gearing between motor and driving axle appears necessary to secure the greatest all around advantages at the lowest first cost.

In answer to the questions asked, it may be said that the control used is an adaptation of the multiple unit control in use on the elevated systems. It permits the operation of the double locomotive from one master controller located in the operating cab of the leading half locomotive; it also permits running two locomotives together and still under the control of one operator. It is a question, however, whether the strength of the draft rigging will ever permit coupling two of these large electric locomotives together at the head end of the train, in as much as the starting effort of one locomotive is 120,000 lb. and the 240,000 lb. starting effort of two locomotives would undoubtedly prove too much for any draft rigging now in use.

The trolley construction used upon the Butte, Anaconda & Pacific Railway comprises a steel catenary from which is hung, by means of loop hangers, a 4/0 copper trolley wire operating at 2,400 volts direct current. The loop hanger permits this trolley wire to ride up and down under pressure of the current collector and independently of its catenary support, and this provides a very flexible form of construction. The result has been that the 5 in. steel tube rollers used to collect the current on the Butte, Anaconda & Pacific have given a life of nearly 30,000 miles when operating in passenger service where the maximum speed approaches 50 miles per hour. The construction being installed upon the Chicago, Milwaukee & St. Paul Railway, is a development of that now in successful operation upon the Butte, Anaconda & Pacific Railway. It utilizes the 4/0 steel catenary and the loop hanger, but provides for two 4/0 trolley wires located side by side and alternately suspended from the same steel catenary. This alternate suspension of the twin trolley conductors provides for extreme flexibility of the overhead conductor, as when the current collector passes beneath the clip of one strap hanger the other trolley wire is hanging free and there is absolutely no tendency to spark, as is the case with the single conductor. Tests made at the Schenectady and Erie Works of the General Electric Company show that 2,000 amperes can be successfully collected at 60 miles per hour and as this corresponds to 6,000 kw. at 3,000 volts, it is considerably in excess of the requirements of one locomotive collector.

The statement can be safely made therefore, that the high-voltage direct-current locomotive can be designed to meet the requirements of the heaviest class of main line service both as regards the capacity of its motors and ability to collect the required amount of current from the overhead trolley wires at any speed called for in passenger or freight service.

LOCOMOTIVE SUPERHEATERS

BY R. M. OSTERMANN, CHICAGO

Member of the Society

THE influence of superheating upon the design and operation of railroad locomotives is quite revolutionary, and much more unusual than upon stationary power plants. The keynote of locomotive design and operation has always been simplicity, and railroad men have maintained an attitude of conservatism well founded upon their experience in operating numerous individual power plants with a high degree of precision and often under conditions adverse to the proper maintenance of any kind of machinery. However, that there are to-day in operation about 32,000 locomotives equipped with just one design of superheater, nearly 12,000 of which are being used on the railroads of this continent, and that a very large percentage of the locomotives being ordered at this time are to be equipped with the device, is a proof that the benefits of superheating are appreciated.

In locomotives, the particular value of an improvement in cylinder performance, or, in other words, of a reduction of weight of steam used per indicated horse power hour, is to be found in the limitations of weight and clearance imposed upon the boiler, limitations which have been felt more and more as the demand for horse power capacity increased.

In proportioning his engines and boilers so as to furnish a given amount of sustained power, the stationary plant designer has no serious difficulties if he can obtain sufficient boiler room space and substantial foundations. His problem resolves itself into choosing, among the known improvements, a combination that will produce the required horse power with a minimum of coal and a maximum assurance of uninterrupted service.

The problem of the locomotive engineer is fundamentally different. He must obtain a certain sustained power from a boiler limited in weight to what is required for adhesion and in bulk by what road clearance and track curves allow.

The desire to increase the operating efficiency of existing track, the inability of the railroads to reduce grades in pace with the development of the traffic in many cases and the recent introduction of all-steel and steel underframe cars, are factors that are responsible for the rapid growth of weight and power of locomotives in this country. The average weight has been increasing rapidly. The boiler barrels of locomotives have reached their practical limit in diameter, and their length has also greatly increased with the increase in the number of driving axles to safely take care of the larger adhesion weights corresponding to the increased cylinder power.

A comparison of heating surfaces in stationary and locomotive boilers is very instructive. While in stationary boilers a square foot of heating surface is provided for evaporating from 4 to 7 lb. of water per hour, locomotive boilers have to evaporate as much as 20 lb. or more per sq. ft. of heating surface. Some recent Pennsylvania tests indicated evaporations of 23.3 lb. per sq. ft. of heating surface under forced conditions and with coal fuel.

In view of such extraordinary figures, illustrating better than any arguments could the limitations of steam generating

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in locomotive operation, any device that would reduce the pounds of steam per indicated horse power hour and at the same time could be applied without materially impairing the boiler efficiency or greatly increasing the weight of the locomotive, two important considerations, would afford material relief; and a correctly designed locomotive superheater is such a device.

The prevailing type of locomotive superheater is shown in Fig. 1 and a unit in detail in Fig. 2. More than 11,000 superheaters of this design are now in use in this country. This superheater is of the firetube or, more generally speaking, of the parallel-flow type, in distinction to the smokebox superheater which operates on the series principle or, in other words, utilizes the heat of the gases left after their contact with the evaporating surface.

Fig. 3 is a curve showing a general relation between coal consumption per indicated horse power hour and superheat, in a more intense action of the superheater in decreasing the specific steam consumption of the locomotive.

The saturated steam locomotive boiler does not possess any boosting feature. On the contrary, the moisture in the steam fast increases, making the saturated locomotive fail when forced.

The benefit of the superheater in boosting the steam temperature and power of the locomotive probably finds its limit at the point where too great an increase of cut-off halts a further reduction of specific steam consumption. Just at what speed and power this takes place depends upon the proportions of the boiler, as compared with the cylinders and wheels; and the problem of the designer is to provide a boiler with proper proportions of evaporating and superheater heating surface so that the largest possible amount of sustained horse power can be had at the speed at which the engine is required to operate normally.

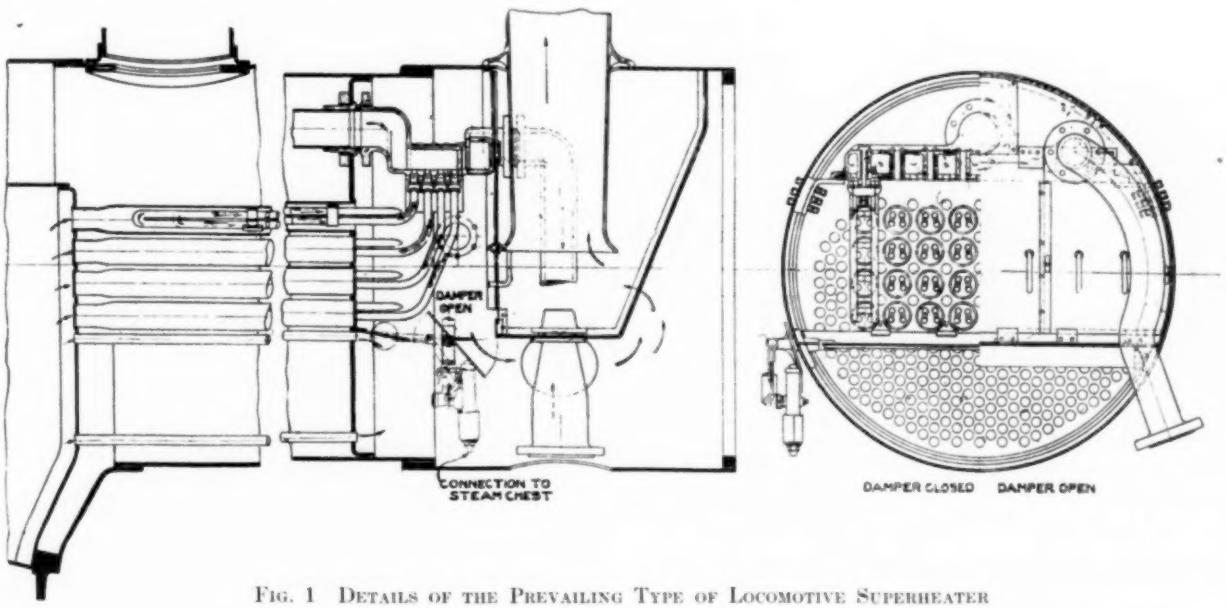

Fig. 1 Details of the Prevailing Type of Locomotive Superheater

as experimentally established by Dr. W. F. M. Goss, to whom we are greatly indebted for a thorough investigation of the [illegible] of superheating carried out on a locomotive at the Purdue testing plant. The curve is interesting in so far as it clearly shows the larger proportionate economies with increase in steam temperature.

The Pennsylvania Railroad has also carried out extensive tests at its Altoona testing plant, and the bulletins issued by this company giving the results of these tests are recommended to all who wish to make a detailed study of locomotive fire-tube superheaters. The tests fully confirm the claims made by the designers of this type of superheater, and show the following fundamental relations:

The superheat increases at a nearly constant rate with the indicated horse power of the locomotive. It also varies in a generally similar manner with the draft and the rate of evaporation, both of which are automatically regulated to suit the load of the locomotive through the agency of its exhaust. The superheater is, therefore, an effective power booster for the locomotive, and this is a very valuable feature from an operating standpoint. An increase in the steam demand upon the boiler necessitates the evaporation of more water per square foot of evaporating surface, which latter results

A comparison of indicator cards taken from saturated steam and equally-sized superheated steam locomotives for either equal power output or equal steam consumption or water rate is most impressive. This comparison can be found in the above-mentioned Pennsylvania reports. In a locomotive, the area of the indicator card is indicative of haulage capacity. The greater the area of the card at a certain speed, the more tons can be hung on the drawbar, and the greater the earning capacity of the locomotive. The addition of a correctly-designed superheater makes it possible to increase greatly the area of the card at a certain speed, and therefore to increase the haulage and earning capacity beyond that of a saturated steam locomotive by increasing the cut-off or by "dropping her down," and still retain the balance between steam generation and consumption.

Savings in coal and water per unit of power developed, such as shown by the tests, are now being obtained in everyday operation. As a rough average, a coal saving of 25 per cent and a corresponding water saving of 35 per cent, while the engine is performing useful work, can be expected, and thermally accounted for, with the knowledge we have of the average amount of cylinder condensation which takes place in saturated steam locomotives.

Comparing two locomotives with identically the same engine and wheels—a case which presents itself often when a superheater is applied to an existing saturated steam locomotive—and assuming further that it would be possible to take sufficient horse power out of the superheater engine so that it burns the same quantity of coal per hour as the saturated engine without an appreciable increase of coal consumption per indicated horse power developed, then on the basis of the fact that the superheater engine can produce one horse power hour at 25 per cent less coal than the saturated engine, we can inversely figure that the superheater engine has 33⅓ per cent more cylinder horse power and from 45 to 55 per cent more drawbar horse power available than the saturated engine.

In operating terms, drawbar horse power is tractive power times speed of train. For the same speed of both engines and trains under comparison, the drawbar pull is about proportional to the tonnage, so it would seem that the superheater engine can haul 45 to 55 per cent more tonnage at the speed of the saturated locomotive working at a correspondingly larger cut-off than the latter. That is, however, practically impossible for the following reasons. The superheater locomotive has no more starting effort than the saturated locomotive of the same engine dimensions; particularly on poorly graded roads, the starting feature governs the tonnage which can be handled. Besides, the specific coal consumption naturally increases as the cut-off is increased, on account of decreasing cylinder efficiency; and how much this factor does towards preventing too great an increase of tonnage depends upon the cut-off at which the saturated engine had to be worked, whether over or underboilered.

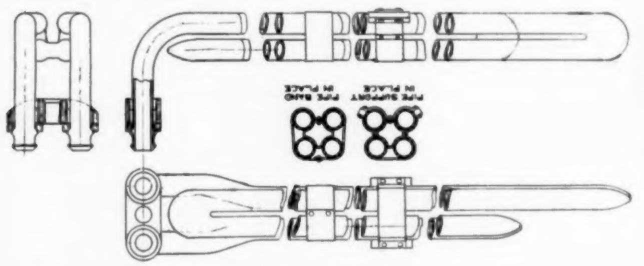

FIG. 2 DETAILS OF THE UNIT OF THE LOCOMOTIVE SUPERHEATER

An increase of speed is often possible in practice in order to utilize the greater drawbar horse power available. In that case, the drawbar pull increases also per ton of train handled; but all the excess of drawbar horse power as potentially existing can hardly ever be utilized in practice. Therefore, part of the benefits of superheating must always be reaped in the form of saving in fuel and water and in the physical efforts of the fireman.

It is as much as stated above that the proportions of the superheater within the given locomotive boiler determine the curve of sustained horse power available at various speeds. These proportions are actually characterized by the ratio of resistances to the flow of the two parallel streams of gases, the one flowing through the large flues in contact with the superheating and the evaporating surfaces, and the other in contact with the evaporating surface only. For a given length of boiler this ratio is dependent upon the ratio of net internal area through the large tubes and through the small smoke tubes; and upon it depend the steam temperatures obtained in the cylinders at various power outputs, which is the power boosting and economizing feature of the firetube superheater.

At the present time, locomotive superheaters are so designed that temperatures of about 620 to 650 deg. Fahr. are obtained for maximum sustained horse power. The steam temperature is of incidental interest only; and it is not the purpose of the design to reach a certain temperature. What is required is a maximum increase of sustained power from a given locomotive. The more superheater units are applied, the more highly can the steam be superheated; but also the greater is the sacrifice of evaporating surface, and, in consequence, the misgivings of the designer of olden days. The intrusion of the superheater units into the boiler meant a compromise; but the influence of superheating upon specific steam consumption is so great that the net result is a tremendous gain.

Fig. 4 suggests that still greater fuel economies and power increases than at present obtained can be had from the superheater that produces higher steam temperatures; but, from what is above stated, it would not be practical unless it required only a comparatively small sacrifice of evaporating surface. This aim can be achieved with a superheater of a similar parallel flow or firetube type which provides for a still closer juxtaposition of superheater and evaporating surfaces and for an arrangement of superheater surface within still smaller smoketubes than does the present superheater. With such a device, it is possible to obtain a more effective abstraction of heat from the gases and obtain higher superheats without sacrificing boiler efficiency. Such an arrangement is actually in use now in Europe, and its introduction in this country may be possible in time. The hope of further increasing the benefits to be derived from locomotive steam superheating was expressed by George L. Bourne, in his discussion of the report of the sub-committee on Railroads at the Annual Meeting, in December, 1914.

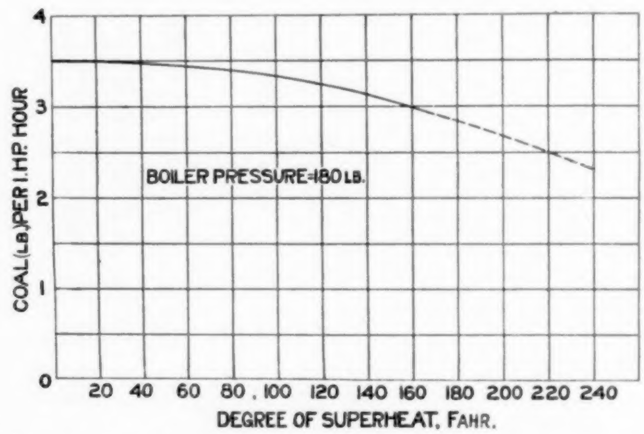

FIG. 3 CURVE SHOWING RELATION OF COAL CONSUMPTION TO DEGREE OF SUPERHEAT

Through systematic efforts on the part of railroads, a number of problems which presented themselves with the introduction of superheated steam in locomotive operation, such as the obtainance of good lubrication, power maintenance at roundhouses, etc., were attacked and successfully solved in a short time; and there appears to be no logical reason why the problem incidental to the use of still higher steam temperatures could not also be solved.

THE WASHBURN SHOPS OF THE WORCESTER POLYTECHNIC INSTITUTE

BY GEO. I. ALDEN, WORCESTER, MASS.

Member of the Society

THE germ thought to which the Washburn Shops trace their origin doubtless existed first in the mind of Ichabod Washburn, the founder of the Washburn and Moen branch of the American Steel & Wire Company, at present a branch of the U. S. Steel Corporation. The first paragraph in Mr. Washburn's letter of gift to the Trustees of the Institute reveals the blending of purely practical, with high moral and ethical, ideals. He says:

"I have long been satisfied that a course of instruction might be adopted in the education of apprentices to mechanical-employments, whereby moral and intellectual training might be united with the processes by which the arts of mechanism, as well as skill in the use and adaptation of tools and machinery are taught, so as to elevate our mechanics as a class in the scale of intelligence and influence, and add to their personal independence and happiness, while it renders them better and more useful citizens, and so more like our Divine Master, whose youth combined the conversations of the learned with the duties of a mechanic's son, and whose ideas and teachings now underlie the civilization of the world."

It was long before this letter was written that Mr. Washburn had conceived the idea of a school for apprentices. He had conferred with Rev. Seth Sweetser, D.D., about his plans, but during the Civil War the project "slumbered." Before the consideration of this plan of Mr. Washburn's was revived, John Boynton of Templeton, Mass., had offered \$100,000 to endow a school to be located in Worcester. Mr. Boynton's gift was accepted, and a corporation was formed fifty years ago. Trustees were chosen, who made plans for the new school which were such as to include Mr. Washburn's ideas. Mr. Washburn finally very heartily consented to build and endow the Washburn Shops as a department of the Worcester County Free Institute of Industrial Science, now designated more briefly as the Worcester Polytechnic Institute. In doing this, he relied upon the other departments of the Institute to do the purely academic work required in the instruction of the apprentices.

In his letter of gift, Mr. Washburn provided for the appointment of a superintendent of the shops, specifying quite fully his duties. He recognized that the plan was an experiment, and stipulated that in case the trustees felt that the plan proposed could not be successfully and advantageously carried out, that it might be abandoned and the funds given for the support of the shop might be used for the benefit of the "main design of the Institute," mentioning the department of Mechanical Engineering in that connection, and stipulating that in such case a part of the income of the funds should be given to needy and deserving students to aid them in pursuing their education.

The purpose of the establishment of the Shops, as it existed in the minds of Mr. Washburn and the original trustees of the Institute, was to combine more closely theory and practice in the teaching of engineers. Mr. Washburn desired and enjoined that the apprentices should have instruction in the school in those branches of science that had a bearing upon their problems and work in the shop. The trustees intended that, by means of the shop practice, the students should be taught how to make their knowledge of science valuable to the industries of the County; that they should combine skill in the methods and practices of the mechanic arts with adequate knowledge, intelligence and understanding of the sciences underlying these processes.

The first notable achievement of the Shops is their continued existence and usefulness, although the establishment of the Shops as a part or department of the Institute was clearly recognized by the founder and original trustees as an experiment. Indeed, the lines upon which the Institute itself was planned were, for those times, so original, and such a departure from recognized types of education, that the trustees declared their unwillingness to put in charge of the Institute, either as President or the heads of the leading departments, any of the experienced and successful educators of that time; for they realized that the traditions of the established educational routine had such a hold upon the men who had espoused the cause of education, that any plan which included any radical departure from methods then existing would have little chance of success under the direction of the trained and experienced educators of that day.

If there were some who acquiesced in the value of technical training, there were apparently none who could tolerate instruction in a commercial shop or could see any connection between commercialism and education. They felt that there could not have been anything learned in making a product that was afterward sold. The aim, however, in making the goods in a commercial shop was not primarily to sell them, but to have them made by correct methods and up to commercial standards. They would be fit for the market, and, being fit, would likely be sold. The fact that the student knew that the goods he helped to make were standard, and not destined to find their way immediately to the scrap heap, had a fine influence upon the mind and the work of the students.

The second achievement is that the Shops have proved that it is possible and practicable for commercial shops devoted to instruction to be largely or entirely self supporting. The record shows that there have been periods in the history of the Shops during which even a considerable balance of profit has been shown. This condition requires more than simply manufacturing goods that go into the market; it means the highest order of business management and that the shop must have a business. It means that the students may learn in such a shop not simply the correct mechanical processes, but how to produce at a profit and that an opportunity is given the student for instruction and practice in

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Presented at a meeting of the Worcester local section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, on June 8, 1915, in connection with the Celebration of the 50th Anniversary of Worcester Polytechnic Institute.

shop administration and management coincidentally with the period of his scientific and cultural studies.

A third achievement is that the Washburn Shops, by their plan and practice, have established the fact that the only place in which to teach successfully the application of science to the mechanical industries is the commercial shop. Every argument used in the years around 1870 in support of the plan of Mr. Ichabod Washburn and the trustees of the Institute is used today by the advocates of practical training for engineers.

The fourth achievement of the shops by which they must be mainly judged as an educational force is their benefit to the students who have been trained in the shops. The persistence of the shops through a long period of opposition; their financial record; their sound principles; all these are not to be regarded as ends in themselves, but only as the means to the attainment of a much higher aim, viz.—a better

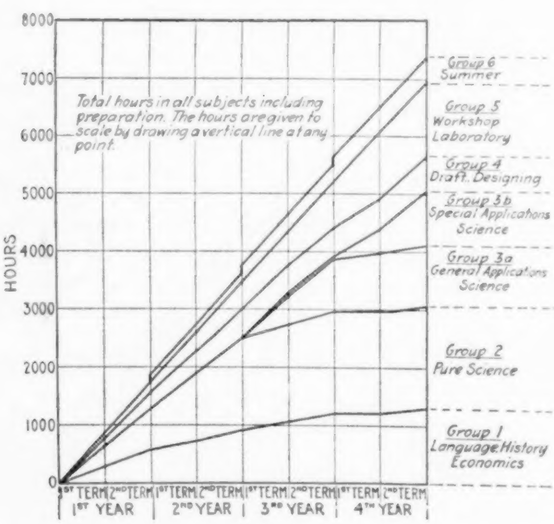

FIG. 1 CHART SHOWING DISTRIBUTION OF HOURS IN MECHANICAL ENGINEERING AT WORCESTER POLYTECHNIC INSTITUTE

type of education for young men pursuing the study of mechanical or allied branches of engineering. The shop courses, covering operations in cabinet work, in pattern making, moulding, core-making, smelting, and all foundry processes, forging, blacksmithing, machine shop practice, machine design, selection of suitable material of construction, care of tools, familiarity with the materials for water and steam piping, care and operation of steam boilers, steam and other engines, handling of repair jobs, experience with cost systems, accounting, efficiency methods, as applied to the organization of business and the production of manufactured products; all these and other kindred features have, by general consent, resulted in great benefit to the more than 700 students who have graduated from the Department of Mechanical Engineering at the Institute, not to mention those who had shop training in connection with their course in Electrical Engineering.

The shop instruction and practice, however, have never taken the place, or reduced the amount of, instruction in the theoretical studies and in laboratory work, either in range or quantity below that of other first rank technical schools. In illustration and proof of this statement, I am permitted by President Ira N. Hollis, of the Worcester Polytechnic Institute, to refer to his article entitled "Technical Education for the Professions of Applied Science," to be published by the Engineering Congress of the Panama Exposition. He compares the course in mechanical engineering in the Massachusetts Institute of Technology, the University of Michigan, and the Worcester Polytechnic Institute by giving the total hours in all subjects, including preparation. The studies in each school are divided into seven main groups, as follows:

Group 1 —Language, History and Economics
" 2 —Pure Science
" 3a—General Applications of Science
" 3b—Special Applications of Science
" 4 —Drafting and Designing
" 5 —Field and Laboratory
" 6 —Summer Work
" 7 —Physical and Military

The total hours in each group and for each of the schools mentioned, are approximately as follows:

	Wor. Poly. Inst.	Mass. Inst. Tech.	Univ. of Mich.
Group 1	1300 hr.	850 hr.	1200 hr.
" 2	1750 "	1550 "	1500 "
" 3a	1100 "	1250 "	900 "
" 3b	900 "	925 "	1950 "
" 4	550 "	550 "	250 "
" 5	1250 "	625 "	650 "
" 6	500 "	....	300 "
" 7	....	100 "	....
	7350 "	5850 "	6750 "

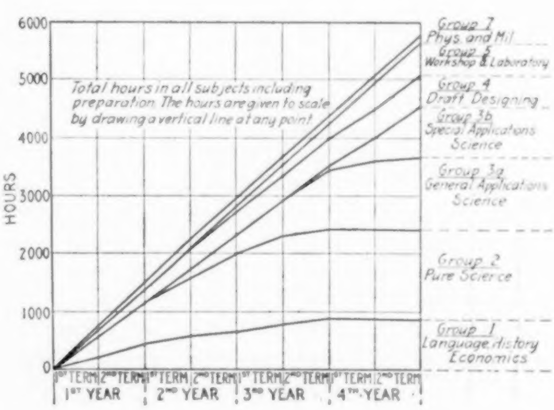

FIG. 2 CHART SHOWING DISTRIBUTION OF HOURS IN MECHANICAL ENGINEERING AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The advantages resulting from a course such as this are many. The fundamental conditions for the type of instruction illustrated by the Washburn Shops are, as we have seen, commercial shops, and the distribution of shop practice throughout the entire engineering course. The first of these conditions secures a degree of shop experience as broad as the shop business permits. The second gives opportunity to bring the theory of the academic work into close and continuous relation to the shop practice. The consideration of the advantages of the commercial shops involves the question of the value and advantage to the young engineer of

shop experience. The manufacturing shops of the country are the connecting link between theory, invention, design, on the one hand, and shop production on the other hand. It is in the shops that theories are modified and perfected, that inventions are made to materialize and become useful, that designs are corrected to conform to the necessities of possible and economical production. The shops stand in a relation to the technical schools of the country similar to that of hospitals to schools of medicine and surgery. Surgeons cannot be produced without hospital practice and experience. The engineer needs to have had shop practice for the same reason that the surgeon needs to have had hospital practice and experience.

That the engineering student should get advantages from experience in connection with so indispensable an agency for the carrying out of all engineering enterprises seems hardly to need emphasis. It may, however, be pertinent to mention specifically some of these advantages:

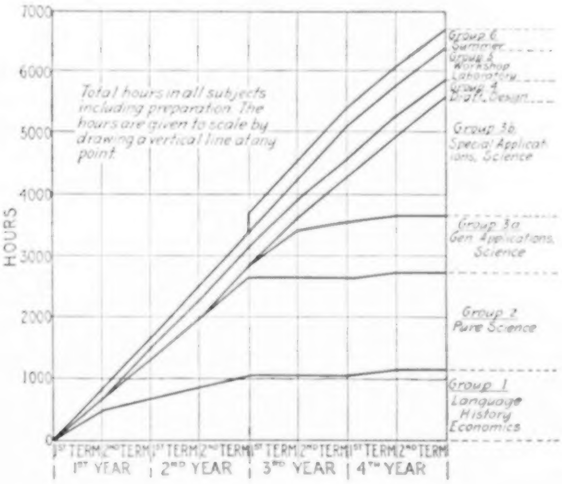

Fig. 3 Chart showing Distribution of Hours in Mechanical Engineering at University of Michigan

First. The possession of mechanical skill has a value which is sometimes much underestimated. It gives one confidence in himself as an independent producer of something worth while—of something which has pecuniary value to him. It gives the young engineer a much better start and insures him a more rapid advancement in his profession. It enables one to direct mechanical operations with confidence and success, and thus gives the young graduate an entrance to one of the most important and promising fields for advancement, viz., the directing and management of skilled men. This is of particular value to men who hope to have a manufacturing business of their own.

Second. Shop experience helps one to get an early start in his profession. The most common question, and often the most pathetic as well, which confronts the graduate is, not what do you know, but what can you do? The man with shop experience of the kind under present consideration can say to the employer, in answer to this question, I can make patterns; have done some work in a commercial foundry; can operate ordinary machine tools; can install a system of keeping costs of production; make working drawings for use in an up to date shop; and if you are likely to have any employment in other lines of engineering work for which my education has also fitted me, I would be glad to start at almost any practical work that offers. To be able, in consequence of shop experience, to make such an answer, may be, and very often is, the key that opens a door of wide opportunity.

Third. The economy of time which is secured by gaining shop experience from weekly practice in a commercial shop, during the whole period of technical training, is an advantage to the engineering student. The graduate who has had this shop experience may have saved a year or two of time in getting established in his profession or business.

The advantages already mentioned of shop experience are those that mainly accrue to the individual student or graduate. We turn now to a broader subject, the design and standardization of machines or structures and their parts, including the necessary jigs, tools, and accessories. It is in these matters that the engineers, who have risen to high positions without mastering the shop regime, are costing the country and the world vast sums of money by compelling manufacturers to make mechanisms in impractical and expensive ways; by failing to incorporate in their designs and drawings standard bolts, screws, nuts, gears, and many other parts that can be purchased for a fraction of what a small lot can be made for; by neglecting to consider and adopt a design for a casting that can be readily handled in the foundry; by introducing fanciful curves and other forms, which add nothing to the value or beauty of the product, but only greatly to its shop cost. The man with the shop training thinks naturally and inevitably of these things. The man who has had no shop experience, unless he be by nature a prodigy in production, thinks less about these matters, and has not the experience to think effectively.

Also, the designing and constructing of material products involves the maintenance of a business organization. Operation of such an organization has become more complex and more important with the prevalence of large business enterprises. The engineer or manufacturer should understand the functions of each department of the business organization which he serves. The commercial shop offers facilities for acquainting the engineering student with the modern methods of business management and business efficiency by giving him practice in the different departments of the business organization, including time keeping, systems of cost accounting, sales management, bookkeeping, store keeping, draughting room practice, cost estimating, and methods of introduction of efficiency systems; in all these and other allied subjects the commercial shop can offer practice valuable and almost indispensable to an engineer who would master his profession and be able to conduct his practice in harmony with and to the advantage of the whole organism of which he happens to be a part.

Schools for teaching the sciences that underlie the industries were founded in this country at dates preceding the founding of the Worcester Polytechnic Institute, as, for example, the Rensselaer Polytechnic Institute in 1824, and the Lawrence Scientific School in 1847. Hon. Samuel A. Eliot was an able advocate of the plan of offering more advanced scientific courses at Harvard; and, while he was treasurer of Harvard College, the governing boards of Harvard University approved a plan for the establishment of an advanced school of science and literature to be called the Scientific

School of the University at Cambridge; in recognition of the gift by Abbott Lawrence of $50,000, the overseers designated the new school as The Lawrence Scientific School in the University at Cambridge. These schools, and others founded later, all provided for instruction in the sciences that were considered practical, in the sense that a knowledge of these branches of science was necessary to the development of the great engineering, mining, transportation, and other industries.

The result of the training of these schools was a body of educated scientists and engineers. The carrying out of their ideas required a great body of skilled workmen. These workmen were trained by being apprenticed to the various trades. The educated scientists had usually no skill or knowledge of practical, mechanical or construction processes. There was, and to a large extent is today, a broad gap, so far as instruction is concerned, between the trained scientist and the skilled mechanic. This gap has been somewhat narrowed in more recent times by the introduction of laboratories equipped with modern engineering apparatus. But, so far as the training in most scientific or technical schools is concerned, there is still a wide space not yet covered by any well defined system of instruction. In this space have grown up partial and inadequate systems, such as manual training schools, trade schools that do not teach trades, and various independent schools, outlined and directed by almost every grade of talent and attainment except commercial, trade and business experience. But the plan outlined nearly fifty years ago for the Worcester Polytechnic Institute provided for instruction both in the sciences which underlie the industries of the country and their application to the processes and work of the Shops. The plan was harmonious and covered the whole ground. It brought theory and practice together in a direct and simple way. Along with mathematics, pure science and language, the student also would learn the equally important and disciplinary lessons of mechanical skill. While pursuing his engineering studies he would practice production of correct gears, difficult mechanisms, standard machines, prime movers, etc., etc. The adoption of this method of instruction involves connection of some kind with commercial shops; and Mr. Washburn provided for the Worcester Institute this necessary part of the equipment in the establishment and endowment of the Washburn Shops.

The Worcester Polytechnic Institute also has engineering and laboratory courses. It has, as shown in Dr. Hollis' paper, from which we have quoted, all the groups of studies found in engineering schools. It gives more time to instruction and preparation, to both the preparatory and the engineering studies, than the other typical engineering schools with which comparisons are made. It also has shop instruction and practice added, or as a surplus in the account. This showing ought to correct the misinformed and neutralize the false logic of the unthinking.

The training at the Washburn Shops has been improved and expanded from time to time during the past forty-six years to meet new conditions in business management and manufacturing and educational methods. These unique commercial shops, therefore, now enable the Worcester Polytechnic Institute to offer exceptional advantages to the student in mechanical engineering, the course in which they round out and complete.

NEW BUILDINGS OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE local meeting of the Society in Boston, held March 31, 1915, was devoted to the Engineering Equipment of the New Technology Buildings. An illustrated talk was given by Harry Gay, equipment engineer in charge of the work for Stone & Webster Engineering Corporation, and following this Geo. E. Libbey of the firm of Hollis French & Allen Hubbard addressed the meeting. A. L. Williston, president of Wentworth Institute, concluded the meeting with an illustrated talk on the Lay-out of Educational Institutions. References to the remarks of the first two speakers follow.

Mr. Harry Gay described in detail, with the aid of numerous lantern slides, the general plan of the new buildings for the Massachusetts Institute of Technology, now under construction, as well as those contemplated, and discussed the proposed equipment of the engineering buildings and science laboratories. He stated that the water supply system received special consideration on account of the large demand of the hydraulic laboratories. The power station will supply alternating current at 2,300 volts, 60 cycles, to a substation for the electrical engineering department where, by means of special transforming and regenerating equipment of 500 k.w. capacity, currents up to 6,000 amperes and voltages up to 100,000 will be available for experimental purposes.

The group of science laboratories, situated apart from the engineering laboratories, will be most complete in their facilities for precise research work in addition to undergraduate instruction. The engineering buildings will also contain extensive hydraulic, steam and chemical laboratories in addition to the electrical department.

George E. Libbey described the heating, ventilating and plumbing arrangements of the buildings. There are three distinct systems of drainage, the sanitary, the rain water, and the underground. The last is for the purpose of keeping the surface water away from the buildings, insuring dry basements. In the plumbing system, continuous venting is employed, a new practice which is rapidly coming into use, as it requires less pipe and is less liable to stoppages. Forced hot water circulation was considered very carefully for this purpose, but a number of conditions governing the installation favored steam, and these were outlined in detail. Among these were the difficulties experienced in obtaining underground tunnels for suitable piping connections.

The heating and ventilating of the group of buildings presented many difficulties on account of the large amount of apparatus in the buildings. A vacuum steam system of heating was decided upon, with which, by means of thermostats operating automatically controlled valves, the temperature can be regulated within two degrees. In connection with the ventilating, supply fans in the basement take air from the windows and apply it to the interior. It is then collected in ducts and exhausted by discharge fans on the roof. The air for ventilation is tempered by primary heaters automatically controlled by thermostats. In the chemical building, the air is changed eight times an hour, and the fumes from the chemical hoods are abstracted through ducts by a special system of fans on the roof. In all, over 100 large fans, requiring 280 kw., are installed.

TECHNICAL DISCUSSION

A RATIONAL BASIS OF COMPARISON OF THE DUTIES OF ELECTRICAL ELEVATORS AND HOISTING ENGINES

BY ANDREW M. COYLE, NEW YORK

Member of the Society

THE following brief discussion is intended to make clear the mechanical and electrical conditions which enter into and limit the efficiencies of the several types of electrical elevators and hoists now on the market. In view of the recent discussion of this subject at a local meeting of the Society and the apparent lack of a basis of comparison of these machines, it is hoped that the data here given and the simple algebraic formulae, developed some years ago and recently revised, may furnish a working basis upon which the theoretic efficiencies of the several types of machines, and the several systems of *rigging* or methods of installation, may be compared and the power requirements for any given installation definitely computed.

In general, the engines in use fall into three classes: *a*, worm-geared; *b*, spur-geared, and *c*, direct-driven machines. The worm-geared is the most common form of engine for elevator service, and the spur-geared the most common form for general hoisting purposes. The helical or herring-bone gear is a special form of spur gear, and may be treated as such. The traction elevator is a special form of rope drive, and may be so treated regardless of whether the traction sheave is driven by means of gears or by a directly-attached motor. For convenience of reference, diagrams are given which show the arrangements of rigging most commonly used with electric elevator and hoisting engines.

EFFICIENCY

As it is desirable to compare the efficiencies of the several types of machine and several methods of installation, it will be convenient to make a general summary of the elements which enter into the problem. An electrical elevator or hoisting installation consists of: 1. A motor; 2. A system of electrical switches and resistances by which the motor is controlled; 3. A drum or sheave driven by the motor, either directly or by means of gearing; 4. A cable transmission to which is attached a car, and usually a counterweight; 5. A brake pulley and brake usually located on the motor shaft; and 6. Certain governing and safety devices which, though of great importance, do not affect the efficiency of the installation. It is quite obvious that electrical engines used for general hoisting purposes will come under the same mechanical laws, and may be treated by the same formulae as are applicable to elevator machines.

The actual efficiency of an elevator can hardly be expressed by a percentage. The conditions under which they operate are extremely variable. The total current consumed by a machine per car mile when performing a specific duty is the only proper basis of comparison.

Economy demands that a machine must use current most efficiently when performing the duty for which it is most frequently used. From this it follows that the machine must be designed with reference to this duty. It follows also that, in cases where the loads to be lifted vary between wide limits, a motor must be selected which will give a fair percentage of efficiency under the varying conditions. Commercial motors which are designed for continuous duty are rarely suitable for elevator service. The attempt to use such motors has led to the installation of a great number of inefficient, costly and unsatisfactory elevators.

It will be convenient to develop a few simple formulae which may be applied generally to determine the quantity of current which should be required to perform any given duty with a machine of any one of the standard types.

The energy developed in the motor is used *first*, to impart motion to the system, and *second*, to lift the unbalanced load in the car. As we develop high car speeds, the proportion of current used to produce acceleration increases until a point is reached at which it is not practicable to bring the car to full speed between floors. This limits the speed of elevators for local service.

The masses to which motion must be imparted are the car, counterweight, load, etc., which move in straight lines, and the drum sheaves, armature, etc., which rotate about their centers. In computing the inertia of a rotating body, we consider its mass as concentrated at the *radius of gyration*. The radius of gyration may be expressed as a fraction of the actual radius, or as a fraction of the distance from the center to some known point which bears a fixed relation to the actual radius.

The radii of gyration of the armature and brake-pulley may be expressed as fractions of their actual radii, but the radii of gyration of the sheaves and of the drum may be more conveniently expressed as fractions of the distance from the shaft center to the cable center. The patterns of sheaves and drums in common use are quite similar. It will be near enough for practical purposes if we use in our formulae the radii of gyration which have been calculated for a sheave and drum of standard design. If in the case of any particular machine the patterns differ radically from those in common use, other values may be calculated. In Table 1, r is used to indicate the radius of gyration which is to be considered as the ratio between the center of gyration and the measurement to which it is referred.

TABLE 1 RADIUS OF GYRATION OF REVOLVING PARTS

When several parts are assembled on one shaft the center of inertia has been computed for the combined masses

Name of Part	r	r^2
Sheave carrying two or more ropes	0.922	0.85
Winding drum with attached drum neck, gear center and gear	0.80	0.64
Traction sheave with heavy hub and spokes	0.80	0.64
Brake-pulley with solid web and flange coupling	0.707	0.5
Armature and shaft	0.707	0.5

SYMBOLS USED IN ANALYSIS

m = Mass in pounds of the car, counterweights, cables, counterbalance chains and attachments, plus the entire live load. (All these parts move with the same speed.)

m_1 = Mass in pounds of all sheaves (excepting the driving sheave in the case of traction machines).

m_2 = Mass in pounds of drum (or traction sheave), drum neck, gear center and gear.

m_3 = Mass in pounds of brake pulley and flange coupling (if coupling is used).

m_4 = Mass in pounds of armature and shaft.

m_5 = Mass in pounds of intermediate gear, in case of machines having double gear reduction.

m_6 = Mass in pounds of cables in motion, in case of machine having 2:1 rigging.

M = The Mass Aggregate; that is, a mass equivalent to the aggregate of all the masses in the system multiplied by the factors which modify their effective values in the total inertia of the system.

M_1 = Negative Mass Aggregate.

v = Velocity of the car, in feet per second.

v_1 v_2 v_3 v_4, etc. = Velocities of the centers of gyration of the masses having the corresponding subnumbers.

D = Diameter of winding drum or traction sheave, in feet, center to center of cables.

d_3 = Diameter of brake-pulley, in feet.

d_4 = Diameter of armature, in feet.

d_5 = Diameter of intermediate gear, in feet (used in case of machine having double gear reduction).

L = Unbalanced load, in pounds.

F = Foot pounds energy which must be developed by the motor during the period of acceleration to impart the required velocities to the different parts of the system and to lift the unbalanced load.

F_1 = Foot pounds energy necessary to impart the velocities v, v_1, v_2, v_3, v_4, etc., to the masses of the system.

F_2 = Foot pounds energy necessary to lift the unbalanced load during the period of acceleration.

F_3 = Foot pounds energy necessary to overcome friction during the period of acceleration.

F' = Foot pounds energy available to drive the motor during the period of retardation.

T = Average torque required of motor during the period of acceleration expressed in pounds at one foot radius.

T_1 = Torque required of motor when running at normal speed, expressed in pounds at one foot radius.

r_1, r_2, r_3, r_4, etc. = Ratios which the radii of gyration of the masses having the corresponding subnumbers bear to the measurements to which they are referred (see Fig. 1).

t = Time in seconds allowed for acceleration from rest to full car speed.

R = Gear ratio = Number of turns of armature to one turn of drum.

R_2 = Ratio of intermediate gear (used in case of machines having double gear reduction).

P = Percentage of efficiency of rope drive, including an allowance for friction of sheave bearings and hatchway resistance.

P_1 = Percentage of efficiency of gearing.

P_2 = Percentage of efficiency of the intermediate gears (used in case of machine having double gear reduction).

n = Number of turns of armature during the period of acceleration.

h = Height load is lifted during the period of acceleration, in feet.

g = Gravity = 32.18.

STARTING CONDITIONS

Using the symbols defined, we may establish certain relations between the values which they represent.

$$F = F_1 + F_2 + F_3 \ldots\ldots\ldots\ldots\ldots [1]$$

$$F = 2\pi n T \ldots\ldots\ldots\ldots\ldots [2]$$

Since T is the average torque during the period of acceleration and the distance through which the torque acts is $2\pi n$, the above relation is obvious.

$$F_1 = \frac{mv^2 + m_1v_1^2 + m_2v_2^2 + m_3v_3^2 + m_4v_4^2}{2g} \ldots\ldots [3]$$

The values of v_1 v_2 v_3 v_4 may all be referred to v taken as a unit. The radii of gyration of the drum and sheaves are referred to the distance from shaft center to cable center for the reason that the cable center moves with the velocity v. Without considering the diameters of the drum and sheaves, we have:

$$v_1 = vr_1 \quad v_2 = vr_2 \text{ hence } v_1^2 = v^2r_1^2 \quad v_2^2 = v^2r_2^2$$

In the case of the brake-pulley and armature we must consider the gear ratio and the diameter.

$$v_3 = v\frac{d_3r_3R}{D}. \quad v_4 = v\frac{d_4r_4R}{D} \text{ hence } v_3^2 = \frac{v^2d_3^2r_3^2R^2}{D^2}. \quad v_4^2 = \frac{v^2d_4^2r_4^2R^2}{D^2}$$

Substituting these values in equation [3] we have—

$$F_1 = \frac{v^2}{2g}\left((m + m_1r_1^2 + m_2r_2^2 + (m_3d_3^2r_3^2 + m_4d_4^2r_4^2)\frac{R^2}{D^2}\right) . [4]$$

In finding the value of F_3, it may be noted: *first:* The power required to impart motion to the armature and brake-pulley is not affected by the efficiency of the machine; *second:* The power required to impart motion to the drum and gear is affected by the efficiency of the gear, expressed by the percentage P_1; and *third:* The power required to impart motion to the sheaves, car, counterweight, cables, chains, etc., is affected both by the efficiency of the gear and by the efficiency of the cable transmission P. This condition may be expressed:

$$F_1 + F_3 = \frac{v^2}{2g}\left(\frac{m + m_1r_1^2}{P \times P_1} + \frac{m_2r_2^2}{P_1} + \frac{(m_3d_3^2r_3^2 + m_4d_4^2r_4^2)R^2}{D^2}\right) [5]$$

The quantity in the parenthesis in equation [5] is the mass aggregate expressed by the symbol M. It is the total inertia of the system, including friction, which in this case acts to all intents as an increase of mass.

It is obvious that

$$F_2 = L \times h \ldots\ldots\ldots\ldots\ldots [6]$$

By the laws of acceleration

$$h = \frac{1}{2}vt \ldots\ldots\ldots\ldots\ldots [7]$$

Hence

$$F_2 = \frac{1}{2}Lvt \ldots\ldots\ldots\ldots\ldots [8]$$

The number of turns made by the drum during the period of acceleration will be $n \div R$. The circumference of the drum is πD; hence we have

$$h = \frac{\pi Dn}{R} \ldots\ldots\ldots\ldots\ldots [9]$$

From equations [7] and [9] we have

$$2\pi n = \frac{Rvt}{D} \ldots\ldots\ldots\ldots\ldots [10]$$

For running conditions, only the friction of the parts and the work of lifting the load are to be considered.

The above considerations lead to the following mechanical formulae:

Energy required for acceleration

$$F = \frac{1}{2}\left(\frac{Mv^2}{g} + Lvt\right) \ldots\ldots\ldots\ldots\ldots [11]$$

Average torque required during period of acceleration

$$T = \frac{D}{2R}\left(\frac{Mv}{gt} + L\right) \ldots\ldots\ldots\ldots\ldots [12]$$

Velocity which may be imparted in a given time by a given average torque

$$v = \frac{gt}{M}\left(\frac{2RT}{D} - L\right) \ldots\ldots\ldots\ldots\ldots [13]$$

Time required to produce a given velocity by means of a motor having a given torque

$$t = \frac{Mv}{g}\left(\frac{D}{2RT -} + \frac{1}{L}\right) \ldots\ldots\ldots\ldots\ldots [14]$$

Torque required for running

$$T_1 = \frac{D}{2RP_1}\left((1 - P)(m + m_1 + m_2) + L\right) \ldots [15]$$

which holds until the value in the parenthesis becomes zero. When the quantity assumes a negative value use

$$T_1 = \frac{DP_1}{2R}\left(L - (1 - P)(m + m_1 + m_2)\right) \ldots [15a]$$

In selecting a motor to develop torque necessary to produce acceleration it must be noted that the average torque is not simply a mean between the highest and lowest torque developed during the period of acceleration. The average torque developed by the motor must meet the conditions $T = \frac{F}{2\pi n}$ in which n is the number of revolutions made by the armature during the period of acceleration.

Equation [15] represents the running conditions of geared machines in general. In the case of the direct driven traction machines R = unity and P_1 takes into account only the friction of the armature bearings. In the case of the 2:1 rigging the value of R is 2.

The following formulae are derived from equation [5]:

FORMULAE FOR MASS AGGREGATE

A general formula for the mass aggregate of a machine having a single gear

$$M = \frac{m + m_1 r_1^2}{P P_1} + \frac{m_2 r_2^2}{P_1} + \frac{R^2}{D^2} (m_3 d_3^2 r_3^2 + m_4 d_4^2 r_4^2) \ldots\ldots [16]$$

in which r_1, r_2, r_3, r_4 are the fractions which express the ratios between the radii of gyration and the actual radii of the rotating parts. For convenience, these fractions have been calculated for the parts of a machine of standard design and the numerical values substituted in the general formula. Unless the machine under consideration is of unusual design these values are sufficiently accurate.

For machine with a single gear ratio, whether worm or spur gear

$$M = \frac{m + .85m_1}{P P_1} + \frac{.64m_2}{P_1} + \frac{R^2}{2D^2} (m_3 d_3^2 + m_4 d_4^2) \ldots [17]$$

For machine having a double gear ratio, either worm or spur gears

$$M = \frac{m + .85m_1}{P P_1 P_2} + \frac{.64m_2}{P_1 P_2} +$$

$$\frac{R_2^2}{2D^2} \left(\frac{m_3 d_3^2}{P_1} + R^2 (m_3 d_3^2 + m_4 d_4^2) \right) \ldots\ldots\ldots\ldots [18]$$

For direct driven machine, either winding drum or traction

$$M = \frac{m + \cdot 85m_1}{P P_1} + \frac{\cdot 64m_2}{P_1} + \frac{m_3 d_3^2 + m_4 d_4^2}{2D^2} \ldots\ldots\ldots [19]$$

For geared machine with 2:1 rigging, either winding drum or traction

$$M = \frac{m + 3 \cdot 4m_1 + 4m_6}{P P_1} + \frac{2 \cdot 56m_2}{P_1} + \frac{2R^2}{D^2} (m_3 d_3^2 + m_4 d_4^2) [20]$$

For machine rigged 2:1 with direct motor drive

$$M = \frac{m + 3 \cdot 4m_1 + 4m_6}{P P_1} + \frac{2 \cdot 56m_2}{P_1} + \frac{2}{D^2} (m_3 d_3^2 + m_4 d_4^2) [21]$$

In formulae [5] and [6] the weight of the traveling sheaves should be included in both m and m_1. m_6 = only the mass of cables in motion, not the standing part.

PERCENTAGES OF EFFICIENCY

The values of P, P_1 and P_2 are necessarily approximate. At the outset we must assume that the machines are properly constructed and properly lubricated. The duty performed in the cable transmission during the period of acceleration is much heavier than that performed under running conditions. In order to express P as a percentage of the load in motion we may use the formula $P = 1 - \left(\frac{aw}{m + m_1} + c \right)$, in which W is the total load carried on all the sheaves and on the drum, a is the loss in one sheave expressed as a percentage of the load on the sheave and c is a constant introduced to provide for hatchway friction. The values of P in the diagrams are based on the values $a = 0.03$ and $c = 0.02$. This is a very liberal allowance for starting conditions. For running conditions the values $a = 0.015$ $c = 0.01$ may be used.

The efficiency of a worm gear may be determined by the formula $P_1 = 1 - (a \times \text{cosecant}\, \phi + b)$ in which ϕ is the pitch angle of the thread, a the coefficient of friction and b a constant added to provide for the power expended in the bearings and in churning the oil.

The efficiency of tandem or balanced worm gearing is not greater than that of a single worm and gear provided with a good ball-bearing thrust. For light loads, the single gear is preferable for the reason that there is less back lash and less difficulty in setting up the machine and in making repairs.

The efficiency of spur and herring bone gears varies from 0.985 in the case of the best cut gears properly lubricated

TABLE 2 VALUES OF P_1 FOR WORM GEAR WITH COEFFICIENT OF FRICTION OF 0.03

Deg.	P_1	Deg.	P_1	Deg.	P_1	Deg.	P_1	Deg.	P_1	Deg.	P_1
8	0.734	11	0.793	14	0.826	17	0.847	20	0.862	23	0.873
9	0.758	12	0.806	15	0.834	18	0.853	21	0.866	24	0.876
10	0.777	13	0.817	16	0.841	19	0.858	22	0.870	25	0.879

TABLE 3 VALUES OF P_1 FOR WORM GEARS WITH COEFFICIENT OF FRICTION OF 0.05

Deg.	P_1	Deg.	P_1	Deg.	P_1	Deg.	P_1	Deg.	P_1	Deg.	P_1
8	0.590	11	0.688	14	0.743	17	0.779	20	0.804	23	0.822
9	0.630	12	0.709	15	0.757	18	0.788	21	0.812	24	0.827
10	0.662	13	0.728	16	0.769	19	0.796	22	0.817	25	0.852

and provided with anti-friction bearings, to 0.93, which will be developed by any cut gears that are set up with a fair degree of accuracy and moderately lubricated.

Table 2 shows values of P_1 for worm gears of pitch angles from 8 to 25 deg., in which the coefficient of friction a = 0.03 and constant b = 0.05. This represents about the best attainable condition.

Table 3 shows values of P_1 for worm gears of pitch angles from 8 to 25 deg., in which the coefficient of friction a = 0.05, constant b = 0.05. This represents average practice.

The pitch line of the worm normally slides on the pitch line of the gear. The angles are determined on those lines. As a matter of fact the angle is variable, being greatest near the roots of the threads and less toward the periphery. Worm gears tend to wear more rapidly than herring bone gears. This wear increases the clearance and causes back lash when the load is reversed. This trouble is particularly noticeable in the case of tandem gears. In the case of the direct driven machine there is no gearing, and P_1 may be given a value of 0.99 which allows for the friction in the armature bearing.

Referring to the equations [16] to [20] it will be noted

that the mass aggregate is composed of two parts. The high speed component, consisting of the armature and attached parts, and the low speed component, which includes all other moving parts. In all geared machines the power required to impart velocity to the high speed parts is a considerable item. It is important therefore to so proportion these parts as to reduce their inertia as much as possible.

Since the gear ratio and the diameter of the armature both enter into the equation as squares, the natural suggestion is to reduce the gear ratio and the diameter of the armature. We cannot do both; a reduction of the gear ratio requires an increase of torque, which cannot be obtained without an increase in the size and weight of the armature, so the two conditions to some extent balance each other.

Another consideration also tends to offset the gain of a low gear ratio. Owing to electrical conditions, we cannot decrease the surface speed of the armature without in a greater measure increasing its size and weight. Very slow speed motors are inefficient, difficult to control and do not readily meet the conditions of varying load.

For the purpose of illustration, let us consider the installation of an elevator in a building in which the rise is 250 ft. We will assume that the car weighs 3000 lb., the counterweight 4200 lb., the chains and cables 3200 lb. and that the maximum load is 3000 lb. In this case, the counterweight is 1200 lb. heavier than the car and the maximum unbalanced load will therefore be 1800 lb. The value of m in the formula will be as follows:

For car *running empty*, m = 10,400 lb.

For car with *balanced load*, m = 11,600 lb.

For car with *full load*, m = 13,400 lb.

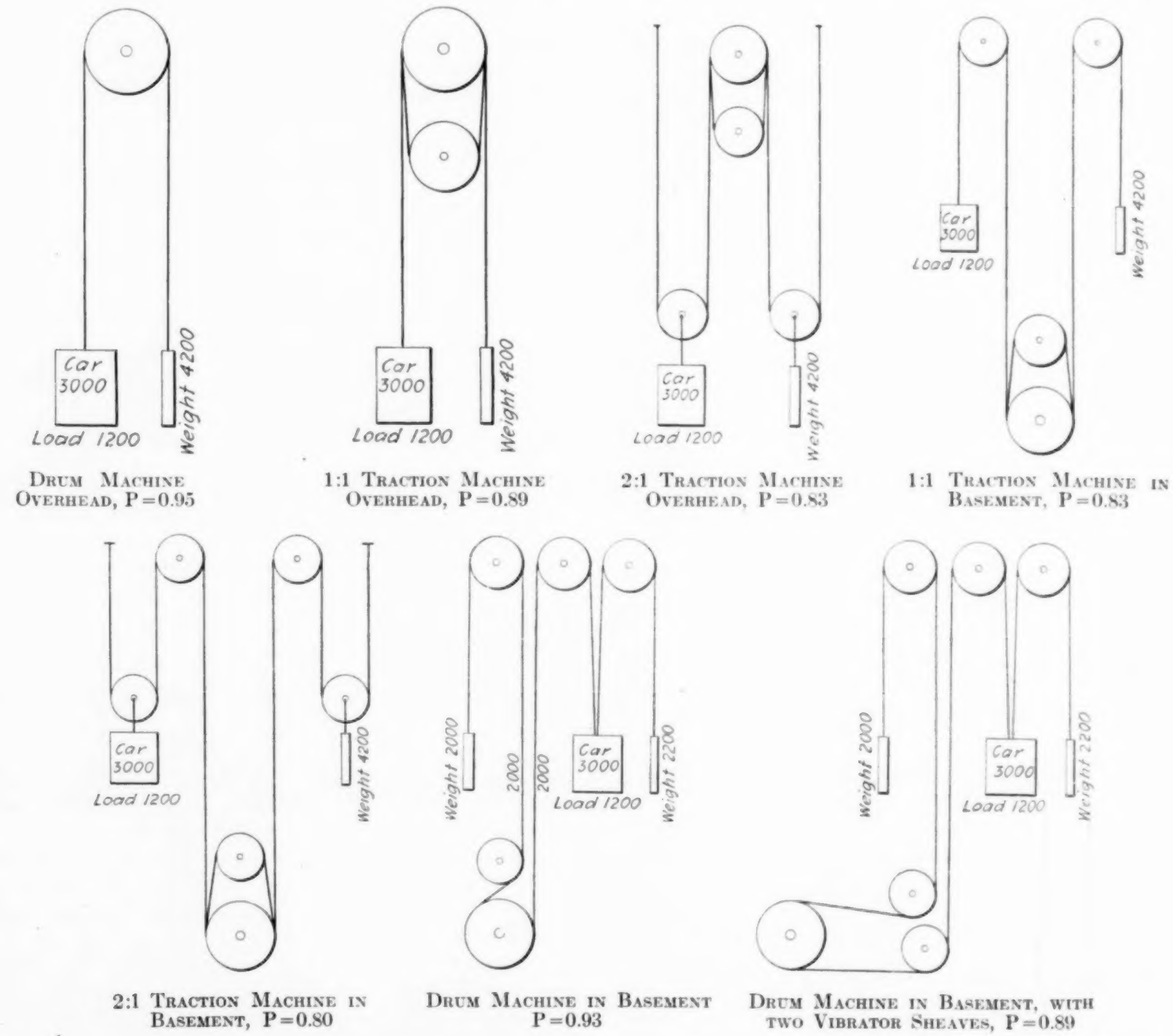

FIG. 1 DIAGRAMS OF THE FORMS OF RIGGING MOST COMMONLY USED SHOWING VARIATIONS IN PRECENTAGES OF ROPE DRIVE EFFICIENCY

In a building of the height stated, it would be usual to install a machine of the overhead traction type. We will, therefore, consider:

FIRST, A direct driven machine; diameter of armature, 32 in. and weight 5000 lb.; diameter of brake-pulley, 36 in. and weight 800 lb.; car speed, 500 ft. per min.; and time of acceleration, 3 seconds.

SECOND, Machine driven by herring-bone gear; diameter of armature, 20 in. and weight 1400 lb.; diameter of brake-pulley, 18 in. and weight 100 lb.; diameter of gear, 36 in. and weight 1000 lb.; gear ratio, 6:1; gear efficiency, 97 per

cent; car speed, 500 ft. per min.; and time of acceleration, 3 seconds.

THIRD, Machine driven by worm gear; diameter of armature, 15 in. and weight 800 lb.; diameter of brake-pulley, 18 in. and weight 100 lb.; diameter of gear, 30 in. and weight 800 lb.; car speed, 300 ft. per min.; time of acceleration, 4 seconds; gear ratio, 24:1; and gear efficiency, 0.86.

In each case we will use a traction sheave 36 in. in diameter, weighing 1000 lb., and an idler 32 in. in diameter, weighing 700 lb. It should be here noted that, in the cases of the geared machines, the diameter of the driving sheave and gear can be increased without increasing the size of the armature. In the case of the direct driven machine this is not possible. The use of a 42-in. sheave slightly increases traction and very greatly decreases the wear on the cables.

Using the weights and diameters above given in the formulae for mass aggregate, we obtain for the car running empty:

First.

$$M = \frac{10400 + 0.85 \times 700}{0.89 \times 0.99} + \frac{0.64 \times 1000}{0.99} + \frac{800 \times 3^2 + 5000\left(\frac{32}{12}\right)^2}{2 \times 3^2}$$

$$= 12478 + 646 + 2375 = 15{,}499$$

Second.

$$M = \frac{10400 + 0.85 \times 700}{0.89 \times 0.97} + \frac{0.64 \times 2000}{0.97} + \left(\frac{100\left(\frac{18}{12}\right)^2 + 1400\left(\frac{20}{12}\right)^2}{2 \times 3^2}\right)6^2$$

$$= 12736 + 1320 + 8228 = 22{,}283$$

Third.

$$M = \frac{10400 + 0.85 \times 700}{0.89 \times 0.86} + \frac{0.64 \times 1800}{0.86} + \left(\frac{100\left(\frac{18}{12}\right)^2 + 800\left(\frac{15}{12}\right)^2}{2 \times 3^2}\right)24^2$$

$$= 14365 + 1340 + 47200 = 62{,}904$$

It is to be noted that the mass aggregate of the geared machine is much greater than that of the direct-driven machine, and that this is chiefly due to the inertia of the high-speed component. The mass aggregate for the balanced load and the full load, if calculated, will appear as in Table 4.

TABLE 4 VALUES OF M, M_1, *F*, *F'*, *T* and T_1

(See equations [11], [12], [15], [17] and [19])

Machine	Start	Stop	Car Ascending				Car Descending			
No.	M	M_1	F	F^1	T	T_1	F	F^1	T	T_1
EMPTY CAR—1200 LB. OVERBALANCE										
1	15500	12627	1735	28637	−208	−1462	31735	−1363	3808	2700
2	22883	18823	9059	35329	194	−189	39059	5312	794	459
3	62904	52493	12450	32463	78	−51	36450	8463	228	130
BALANCED CAR										
1	16862	13683	18206	14780	2184	879	18206	14780	12184	879
2	23673	19855	25563	21443	511	148	25563	21443	511	148
3	64472	53405	25059	20828	156	42	25059	20828	156	42
1800 LB. UNBALANCED LOAD										
1	18905	15264	42911	−6015	5149	3886	−2089	38985	−251	−1678
2	25759	21403	50295	−325	1006	661	5295	44615	106	−247
3	66824	64773	43973	7263	255	186	7973	43000	30	−59

In the case of machine No. 1, the armature makes 53 r.p.m. and has a surface speed of 442 ft. per min.; this is a low speed for electrical efficiency and ease of control. In the case of No. 2, the armature makes 316 r.p.m. and has a surface speed of 1663 ft. per min.; this is a good speed both for efficiency and control. In the case of No. 3, the armature makes 760 r.p.m. and has a surface speed of nearly 3000 ft. per min., which is not required for electrical efficiency or ease of control. There is no excuse for using this high speed motor excepting low first cost.

Having found values for F, T, T_1 corresponding to the specified values of v and t, we may proceed to the motor. If we are in possession of full data concerning the motors available for use, the formulae will show at a glance the most suitable motor. If no motor at hand will meet the condition, it will be necessary to change either the velocity or the time of acceleration.

It will be convenient to develop a few simple formulae which will give us an approximate estimate of electrical requirements. The following electrical symbols are assumed:

Q = Energy in kw-hr. used per car mile in one direction for all purposes.
q = Energy in kw-hr. used per car mile in making starts.
q_1 = Energy in kw-hr. used by motor per car mile running at normal speed.
q_2 = Energy in kw-hr. used by the motor per car mile exclusive of the distance traveled during the period of acceleration and retardation.
q_3 = Energy in kw-hr. used per car mile during period of retardation.
q_4 = Allowance made per car mile for current used in relay and brake magnets (watt-hr.)
y = Energy lost in starting resistance during the period of acceleration (watt-hr.).
y_1 = Energy lost in stopping resistance during the period of acceleration (watt-hr.).
p = Percentage of efficiency of motor when operating under overload conditions to produce the torque T.
p_1 = Percentage of efficiency of motor when operating under running conditions to produce the torque T_1.
K = Mechanical equivalent of 1 kw-hr. = 2,654,200 ft.-lb.
E = Line voltage.
N = Number of starts made per car mile.

The items q_4 y and y_1 depend on the type of control used, and the extent to which the speed of the motor can be governed by field regulation. They are practically fixed quantities which enter into the equation each time the controller operates.

ELECTRICAL FORMULAE

The car makes N starts per car mile and at each start F ft.-lb. of energy are used. We also have to consider the electrical efficiency of the motor and the loss in the resistance:

$$q = \frac{FN}{Kp} + Ny \ldots\ldots\ldots\ldots\ldots\ldots [23]$$

The number of turns made by the armature per car mile is $\frac{5280R}{\pi D}$ and at each turn the energy used is $2\pi T$ ft.-lb.

The running current per car mile will be

$$q_1 = \frac{5280 \times 2RT}{DKp_1} = \frac{RT_1}{251Dp_1} \ldots\ldots\ldots [24]$$

During each period of acceleration and retardation the car travels a distance approximately ½vt at less than full speed. The total distance traveled at reduced speed in one car mile is Nvt feet. Hence the distance traveled at full speed is $5280 - Nvt$.

$$q_2 = \frac{2RT_1\,(5280 - Nvt)}{DKp_1} \ldots\ldots\ldots\ldots [25]$$

Each time the car stops, a certain quantity of current is either used or generated and a certain quantity is lost in the resistances.

$$q_3 = \frac{F'Np}{K} - Ny_1 \ldots\ldots\ldots\ldots\ldots [26]$$

Ny_1 is negative for the reason that it is a loss, deducted from the generated current.

Summing the several equations

$$Q = \left(N\left(\frac{F}{p} - aF^{1}p_1\right) + \frac{2\pi RT_1}{Dp_1}(5280 - Nvt) \right)$$
$$\div K + \frac{N(y + y_1)}{1000} + q_4 \ldots\ldots\ldots\ldots\ldots\ldots [27]$$

When F, F' or T_1 has a negative value, the part of the equation in which the negation occurs, changes to Fp, $\frac{F'}{p_1}$ or $\frac{2\pi RT_1}{D}$ as the case may be. The time required to run one car mile is (5280 — Nt) seconds; q_4 is estimated as 2.5 amperes for this time.

Table 5 shows the variation between running and starting requirements is great. It is easy to see that the motors must have field regulation; a constant field simply would not meet requirements. There are many constant field motors used in elevator service for slow speed machines. In such cases the period of acceleration is unnecessarily long, the motor is heavily overloaded during this period and a great deal of current is lost in the resistances and in heating the armature.

The compound field is good, so far as starts are concerned, but has disadvantages when stopping. The most satisfactory results are obtained with motors having variable shunt fields and provided with interpoles to govern the commutation. The motor selected for machine No. 2 would have field regulation in the ratio of 1:3; that is, from a slow speed of 106 r.p.m. to the full speed 318 r.p.m. The starting resistance would be in use less than 1 second. The resistance necessary to protect the armature at the instant of starting would be about 1.45 ohms. We will assume that part of this resistance is in use one second at each start. A fair allowance for the current converted to heat in this resistance would be 3.3 watt-hr. per start with full load.

Considering the starting conditions of the motor used on machine No. 1, it is evident that field control cannot be applied to any great extent. In the case of this motor a variation of speed of 1:1½ by field regulation might be obtained. That is the slow speed on strong field might be 35 r.p.m. and the full speed 53 r.p.m. Under those conditions resistance would be used in the armature circuit during a period of about 2 seconds.

The slow speed armature has a high internal resistance, and therefore the external resistance necessary to protect it at the start would not be more than 1.27 ohms. We may consider part of this as being in the circuit about 2 seconds at each start. The current converted into heat in this resistance would be 7.2 watt-hours per start with full load. Considering next the current used in stopping. In the case of machine No. 2, the car speed is reduced to 166 ft. per min. by strengthening the field. During this time a small amount of current may be returned to the line. In the case of machine No. 1, the speed of the car is reduced to 334 ft. per min. by strengthening the field. If F^1 has a large positive value, the speed must be further reduced by means of resistance parallel to the armature. This resistance passes a current of about 40 amperes across the line for a period, depending on the skill of the operator. This resistance is thrown across the line at every stop. In the hands of a skillful operator, the period of its use will be brief when F^1 is small or negative, and will last from 1 to 3 seconds when F^1 is large. An unskilled operator may make considerable runs under negative loads, when the motor, which should be acting as a generator in the line, is merely heating resistance and a current of 40 amperes is passing across the line.

It may justly be assumed that the armature parallel resistance is across the line 1½ seconds at each stop with full load, and on this assumption, for machine No. 1, $y_1 = 8$ watt hours.

The characteristics of a motor when running under uniform load are readily obtainable. For the purposes of hoisting machinery, it is, however, equally important to know the characteristics of a motor during the period of acceleration. This data should be obtained in the testing room, in order that a proper comparison may be made between different motors. Data obtained from tests on elevator machines is not specific for the motor.

The questions which these tests should answer are:

a Having a given load and a given mass to be accelerated, what is the period of acceleration?

b What quantity of current was consumed during the period of acceleration?

c How much of this current was used by the motor and how much was lost in the control resistances?

d What was the number of turns made by the armature during the period of acceleration?

No motor should be applied to hoisting duty until this data is known.

TABLE 5 VALUES OF p AND p_1 EXPRESSED AS PERCENTAGES AND y AND y_1 EXPRESSED IN WATT HOURS

Machine	Empty Car—1200 Lbs. Overbalance								Balanced Car				1800 Lb. Unbalanced Load							
	Ascending				Descending				Both Directions				Ascending				Descending			
No.	p	p_1	y	y_1	p	p_1	y	y_1	p	p_1	y	y_1	p	p_1	y	y_1	p	p_1	y	y_1
1	.50*	.80*	4	6	.80	.90	5.3	2	.90	.85	5.5	4	.75	.85	7.2	1	.50*	.83*	4	8
2	.60†	.82*	2.4	0	.82	.92	3	0	.92	.87	2.8	0	.77	.87	3.3	0	.60†	.85*	2.5	0

* Motor acting as a generator; use $F \times p$. † Small current and low efficiency. The values given are approximately correct for average performance.

TABLE 6 ESTIMATED CURRENT IN KW-HOURS PER CAR MILE

Machine			Empty Car—1200 Lbs. Overbalance		Balanced Car	1800 Lb. Unbalanced Load	
No.	a	q_4	Ascending	Descending	Both Ways	Ascending	Descending
1	1/3	0.15	−0.992	8.24	3.87	12.25	−1.60
2	2/3	0.15	−1.17	7.98	2.85	11.73	−3.11
Diff.	2:1	0	−0.178	0.26	1.02	0.52	−1.51

Average for one round trip under each condition:—Machine No. 1, 4.27 kw per car mile; Machine No. 2, 3.36 kw per car mile. The line to load efficiency of these two machines is nearly equal. The advantage in this particular comparison is with the geared machine, and is largely due to the increased range of field regulation of the motor used with this machine.

From the above, the importance of having full information about the motor, independent of the machine to which it may be attached, is apparent. In conclusion, I wish to state that, while theoretical considerations may not enable us to predict results as accurately as test sheets will show them, no test sheet should be accepted as reliable unless it shows results nearly conforming to calculation based on sound theory.

FOREIGN REVIEW AND REVIEW OF PROCEEDINGS OF ENGINEERING SOCIETIES

ENGINEERING SURVEY

IN the end of 1912, Max Jakob stated that the determination of c_p of steam as a function of v from the Clausius thermodynamic relation is extremely difficult, since it depends on the curvature of the isobars in the vT diagram, which is very slight and can scarcely be determined accurately. As a result, equations which have v correct to one-tenth of one per cent may lead to values of c_p several per cent wrong. Professor Goodenough, in his paper published in Vol. 34 of the Transactions of The American Society of Mechanical Engineers, has, however, given an equation for deriving c_p as a function of v. In the present issue is published an abstract of the report of an investigation on specific heat of superheated steam at pressures from 8 to 20 atmospheres, by Knoblauch and Winkhaus, in which, among other things, it is shown that up to 8 atmospheres, the values from the Goodenough equation differ from those found experimentally by less than 1 per cent; and that even in the region of superheat, at pressures as high as 20 atmospheres, it reaches only 2.5 per cent. As the author states, it is a surprising fact that, notwithstanding the inherent lack of precision in the processes of determining c_p from v, the Goodenough equation gives results in such close agreement with observed values.

THIS MONTH'S ARTICLES

Causes of explosions in air liquefaction plants are discussed. In the same section is given an abstract of a discussion of the theory of wind motors and derivation of a formula for the useful power developed by same.

Data of tests on Diesel engines when running light are given, showing, among other things, the variation of the indicated average pressure as a function of the speed of rotation and load.

In the section Mechanics, are discussed torsional oscillations of an engine shaft; in particular, of a Diesel engine having several cranked members, a flywheel and an additional heavy rotating mass, such as a dynamo. The author gives a general method for the determination of the influence of any number of masses on the vibration of the engine shaft. In the same section is given, in abstract, a statement of the laws of efflux of drops from capillary orifices.

The use of centrifugal pumps on fire engines and a description of the various methods of starting such pumps is discussed in an abstract from a German periodical.

In the section Steam Engineering, in addition to the article on specific heat of superheated steam at high pressures and temperatures above referred to, are given statistical data on boiler accidents in France during 1912 and an abstract of an article on the determination of pressure variations in steam turbines and of dimensions of nozzles by means of the Mollier JS diagram.

In the section on Testing is described the Kapff oil testing machine, and some data are given on the bearing of cohesion and adhesion of oils on their properties as lubricants.

The gas power blower station of the Maryland Steel Company is described in a paper before the American Institute of Mining Engineers.

An abstract of data on tests on concrete, in particular crushing tests and experiences with tremies of various sizes, is reported from the proceedings of the American Society of Civil Engineers.

From the Journal of the Cleveland Engineering Society is taken a very interesting discussion on machine tool development in 1914, showing the trends of development and discussing various new industrial and mechanical features.

The use of electric furnaces for reheating, heat treating and annealing, their field of application and comparative costs, are covered in a paper before the Engineers' Society of Western Pennsylvania.

Henry A. Gardner, in the Journal of the Franklin Institute, reports an investigation of some little understood phenomena in the behavior of paints; in particular, how paints are affected by fungus growths, enzymes and microörganisms.

On a special experimental engine at the University College, Dundee, interesting tests were made on the distribution of heat in the cylinders of a gas engine, reported from an advance paper published by the Institution of Mechanical Engineers.

The subject of pneumatic tubes, both pressure and vacuum, on which there is unfortunately so little published material, is discussed in great detail from rich experimental data by Alec. B. Eason, in the journal of the Institution of Post-Office Electrical Engineers.

Other subjects, such as new methods of the utilization of lignite coal tar, elastic properties of steel at moderately high temperatures, the measurement of the efficiency of domestic fires and handling fuel in extreme climatic conditions, are reported in other sections of the Engineering Survey.

FOREIGN REVIEW

Air Engineering

EXPLOSIONS IN AIR LIQUEFACTION PLANTS AND THEIR CAUSES

There have been several disastrous explosions in plants manufacturing oxygen and nitrogen from liquid air. As a rule, it is quite possible to separate oxygen and nitrogen by fractional distillation in the so-called countercurrent apparatus, but it appears, however, that these apparatus are sometimes subject to highly dangerous occurrences.

The pipes of the column apparatus in which the oxygen is separated from the liquid air have to be thawed out at night because of accumulation of ice. This thawing out process is usually carried out with warm water and, in the meanwhile, the operation of the plant is interrupted. In one case, the attendant was busy thawing out the pipes while a laborer was removing the insulating cork. The foreman had most strictly prohibited the use of a torch, but notwithstanding that the attendant did use one, as he was seen carrying the torch inside. Immediately thereafter, there

occurred an explosion which threw aside heavy iron beams, blew up the roof, killed the attendant and did a lot of other damage. The explosion was followed by a fire. It seems reasonable to believe that the attendant approached with his torch too close to the insulating cork of the column apparatus and in this way ignited the mass. Whether the explosion was due directly to the explosive combustion of the cork or was accompanied by the explosion of illuminating gas has not been established. Tests have shown, however, that the extremely porous cork used in this kind of apparatus accumulates in a very short time such large amounts of oxygen in its pores that it becomes highly explosive.

Another explosion which likewise occurred in an air liquefying plant is also of great interest. It occurred in a plant manufacturing from liquid air pure nitrogen to be used for the production of calcium nitrate. In this case the separation apparatus exploded, mortally wounding the foreman. In this apparatus, the air was compressed to four atmospheres, and was thence led to the liquefaction system where it was allowed to trickle in a column apparatus 3 m. high. The nitrogen evaporated while the oxygen collected in two vessels connected by an overflow. In order to free the nitrogen from the last traces of oxygen, a part of the nitrogen compressed to 100 atmospheres flowed in a thin spiral through the countercurrent helix and through the collector filled with liquid air or oxygen, whence it flowed freely into the upper part of the column. While this was done, the last traces of the oxygen contained in the nitrogen were liquified and flowed down into the collector, and this, as well as the column, was equipped with a safety valve which prevented the pressure therein from exceeding 0.5 atmospheres.

The explosion, which caused a large amount of damage, was not due to excessive pressure, as the presence of a safety valve protected it from that. Two separate detonations appear to have been heard and it seems that the collector was the first to be destroyed, whereupon the oxygen flowing out produced an explosive combustion of the insulating silk. After the first detonation, the foreman rushed to the apparatus but was thrown back by the second explosion, and hurled against a compressor. Previous to that another explosion of a similar nature had taken place, which was ascribed to the fact that in some manner or other the air taken in contained traces of acetylene and that copper acetylide, which is highly explosive, was formed. It does not appear likely, however, that copper acetylide would decompose explosively at a temperature as low as that of boiling liquid air.

The author describes a third explosion which destroyed an entire factory and caused a heavy loss of life. The persons who were in the factory saw a bluish flame, similar to that of lightning, start from the ground. Then a big gray cloud of dust was seen and finally a tremendous detonation was heard, after which the building practically collapsed. Some of the bodies recovered from the ruins were found to be terribly mutilated. The separation apparatus had entirely disappeared and there was an immense hole in the wall near which it stood. From the testimony of the workmen who were in the factory just previous to the explosion, the following is what apparently occurred: The chief engineer and his assistant had started the plant in the morning and it appeared to be working all right. They forgot, however, to blow off the dew which accumulated in the apparatus after it had been standing idle over Sunday and had become somewhat warm. Notwithstanding the most careful cleansing of the air previous to its admission into the liquefaction system, a certain amount of water settled down as ice in the separation apparatus; this had to be melted and removed from time to time. A couple of hours after the plant was started, the foreman inspected it and found everything in order, but apparently the apparatus had simply frozen. When the engineer, who was working the apparatus alone, did not know what to do, he went to the superintendent and was ordered by him to thaw out the apparatus, the superintendent then withdrawing to take care of his clerical work. The engineer, however, notwithstanding strict orders not to bring any fire or hot objects near the apparatus, heated, by a torch, up to red heat, a large wrench used for tightening the stuffing boxes of the expansion valves, and put it into the expansion valve when the insulation of the apparatus apparently caught fire.

Some other cases of explosions in air liquefaction plants are likewise described. From all these, it appears that the causes of explosions may be divided into two classes—one, which is obvious, produced by the prohibited use of an open flame, and the other, less obvious, due probably to some sort of chemical action or freezing.

The author calls attention to the following facts as serving as possible explanations of explosions of the second class. Essentially, air consists of a chemical mixture of oxygen and nitrogen, in addition to which there are present in it, water vapor, carbon dioxide, complex gases and the so-called noble gases, such as argon, metargon, helium, xenon, neon and krypton. The essential properties of these noble gases are that they apparently do not enter into any chemical combination either among themselves or with other gases. The most important of them is argon, of which there is present in the air approximately 0.935 per cent by volume. It liquefies at — 186 deg. cent.; oxygen at — 184 deg. cent. and nitrogen at — 194 deg. cent. In apparatus where nitrogen is produced and where, therefore, a very low temperature has to be maintained, it is quite possible that argon settles down in the pipes, forms an ice-like mass and in this way bottles up the air passages, thus raising the compression of the gas up to the point where it explodes the apparatus.

It is also possible that argon brings about explosions in another manner. Essentially, the noble gases have not a molecular, but an atomic structure; that is, they consist of single atoms. It is, however, possible that this structural property changes at very low temperatures, and in the argon ice the atoms of the gas combine into a complex gas, which dissociates explosively when the temperature rises. Similar explosive dissociations may also take place in the case of peroxide of hydrogen and ozone.

Another source of danger which may cause explosions is the presence of combustible substances in the liquefied air, due, for example, to the penetration of oil from the compressors or perhaps of products of decomposition of lubricating oil formed in the compressors under the influence of the heat of compression. It is also well to bear in mind that in the atmospheric air there are present small amounts of hydrogen and methane, and it is quite possible that if both gases are present in equal amounts they may, after a certain length of time, appear in quite substantial quantities in liquefied air. Considering that air liquefaction plants have usually an output of 400 cu. m. (14,125 cu. ft.) per hour, or 4000 cu. m. per working day of 10 hr., and considering

further that there may quite easily be 0.05 per mil of methane, this would be equivalent to 200 l. (52.8 gallons) of liquid methane, an amount sufficient to create a tremendous explosion in the presence of liquid air or oxygen.

There is one more fact which has to be borne in mind. Ozone may convert hydrocarbons into highly explosive compounds—so-called ozonides or peroxides. Harries produced such explosive compounds even from hydrocarbons having annular formation, such as benzole and toluol, and from other derivatives of methane. Saturated hydrocarbons, such as methane, produce explosive substances of the peroxide type and can be converted into formaldehyde and formic acid. From methane derivatives are also produced ozonides proper, which in most cases are highly explosive, and in the presence of water dissociate into aldehydes and peroxide of hydrogen Unsaturated ketons, aldehydes and single-base acids of fats combine with four atoms of oxygen thereby also forming explosive compounds. It appears, therefore, that unless extreme care is exercised, there are numerous sources of danger in the production of liquid air and its component gases. (*Beitrag zur Klärung der Explosionsursache in Luftverflüssigungsanlagen,* Dr. W. Bramkamp, *Zeits. für komprimierte und flüssige Gase,* vol. 16, no. 12, December 1914, 5 pp. *dp.*)

WIND MOTORS

This paper is a discussion of the theory of wind motors, and derivation of formulae for their design.

Considering an element of a wing resulting from the intersection of a wing by a cylinder of radius r having for its axis the axis of rotation OX, this element rotates about that axis at a speed of n revolutions per sec., and is subjected to the action of a wind blowing at a velocity of V meters per sec. in the direction of the axis. For all points of that element the relative direction of the wind will be the resultant of the velocity of wind V and the tangential peripheral velocity of the element $2\pi nr$. Denoting the angle of this resultant with the direction OX by β, we have the relation

$$\tan\beta = \frac{2\pi nr}{V}$$

The element under consideration is directed along the radius r, so as to make with the direction parellel to OX, an angle $\beta + \alpha$ such that its incidence with the relative wind be α. If we project on the axis OY the two components R_x and R_y of the resistance offered to the element by the air in motion, and multiply these projections by the peripheral speed, we shall obtain an expression for the useful power developed by the element, viz.:

$$dP_n = R_y(\cos\beta - \frac{R_x}{R_y}\sin\beta)2\pi nr$$

This can be expressed as a function of $\tan\beta$ (which, for the sake of brevity, is denoted by z), in which case we shall have:

$$dP_n = R_y V \left(1 - \frac{R_x}{R_y}\; z\right) z \; \frac{1}{\sqrt{1+z^2}}$$

The resistance is

$$R_y = SW^2K_y$$

where $S = L\,dr$ is the area of the element, L being its width; W the resultant velocity, $= \frac{V}{\cos\beta}$, and K_y, unit raising component depending on the section of the element and its incidence α; further, the ratio $\frac{R_x}{R_y}$ can be replaced by $\frac{K_x}{K_y}$. If we substitute these values into the expression for dP_n, we find:

$$dP_n = \frac{LV^4K_y}{2\pi n}\left(1 - \frac{K_x}{K_y}\; z\right) z\sqrt{1+z^2dz}$$

Assuming that the width of wing L is constant, and is a fraction of the radius, say 1/6, we have

$$L = \frac{r}{6} = \frac{Vz}{12\pi n}$$

where z is that value of $\tan\beta$ which prevails at the top of the wing. Taking further that the wing is made up by placing side by side, along the radius r, elements similar to the one just considered, all directed in the same way as it with respect to the resultant of velocities, so that the ratio $\frac{K_x}{K_y}$ is everywhere the same, we can find the formula for the useful power of a wind motor having a wings, by integrating the expression for dP_n between the limits $z_0 = 1$ and $z_1 = Z$:

$$P_n = \frac{aV^5K_yz}{24\pi^2n^2}\int_1^z\left(1 - \frac{K_x}{K_y}z\right)z\sqrt{1+z^2dz};$$

on carrying out the integration between the above limits, we find:

$$\tfrac{1}{3}\sqrt{1+z^3} - 0.94 + \frac{K_x}{K_y}\left[\frac{1}{8}z(1+2z^2)\sqrt{1+z^2 -} \right.$$
$$\left. z + \sqrt{1+z^2}) - 0.64\right].$$

If we denote by $-A$ the term by which $\frac{K_x}{K_y}$ is multiplied, and by B the second term, we obtain

$$P_n = \frac{aV^5K_yz}{24\pi^2n^2}\left(B - \frac{K_x}{K_y}\,A\right),$$

where A and B are positive within the limits of integration. This expression shows that as z increases from $z = 1$, the values of P_n are positive, that they start from zero and rapidly increase, and that P_n again becomes zero for a value of z such that $B = \frac{K_x}{K_y}A$. The author shows how the maximum value of P_n is determined. (*Sur les moteurs à vent,* M. Drzewiecki, *Comptes rendus des séances de l'Académie des Sciences,* vol. 160, no. 16, p. 513, April 19, 1915, 4 pp. *tm.*)

Firing

NEW METHOD OF UTILIZING LIGNITE COAL TAR

Lignite coal tar obtained as a by-product from gas producers is usually quite unwelcome because there is no use for it and its elimination involves trouble and expense. Because of its high content of water (up to 40 per cent) it is not commercially profitable to handle. The author in this connection has proposed to reintroduce the tar into the gasification chamber of a producer gas furnace and to gasify it there. This was done and it was found that the otherwise undesirable high water content did not matter here because the water escaped together with the tar, vapors and ammoniacal water and tar coming from the hard coal. A part of the tar vapor, mainly the heavier hydrocarbons, remained, however, in the gas.

The tests were carried out in the following manner: The tar was thrown in the gasification chamber of a producer on the glowing coke cakes and the gas generated in that cham-

ber was carried away through a separate pipe direct to the apparatus in the testing laboratory, the tar produced in that chamber being also handled separately. The lignite coal tar was added during the period from the 20th to the 23rd hour of gasification; that is, it was stopped just one hour before the taking out of the coke cake. The amount of tar supplied was 100 kg. (220 lb.), approximately the same as is taken out in producer gas production per chamber.

The tests have given the follownig results. Before the beginning of the coal tar additions, the gas had an average heating value of 3580 calories (6444 B.t.u. per lb.) at zero deg. cent. and 760 mm. barometric pressure. During the period of addition of the tar it stood around 3950 calories (7110 B.t.u. per lb.), which indicates that unless the lignite coal tar were added, the heating value of the gas during these three hours would, instead of rising, have sunk from 3580 to 3420 calories and probably even below that. The author shows further that the gases produced from the tar were equivalent to 229,600 calories, equal to 44 cbm. of gas of 5200 calories (9360 B.t.u. per lb.).

The author goes through a detailed calculation and shows that in the above escaped gas the lignite tar had at least a value of 3.40 marks per 100 kg. ($0.36 per 220 lb.). (*Ueber ein neues Verfahren zur Verwertung des Braunkohlenteers,* Viktor Schon, *Journal fur Gasbeleuchtung,* vol. 58, no. 17, p. 216, April 24, 1915, 2 pp. *d.*)

Tests on Diesel Engines when Running Light

No-load runs on Diesel engines can be classified in three groups: *First,* no-load runs without ignition in the cylinder, which occur, for example, when, in a two-cylinder motor, one cylinder drags the other; *second,* no-load runs with ignition but without load, in which case only enough power is developed in the cylinder to overcome friction; and *third,* running light with ignition under load on the engine.

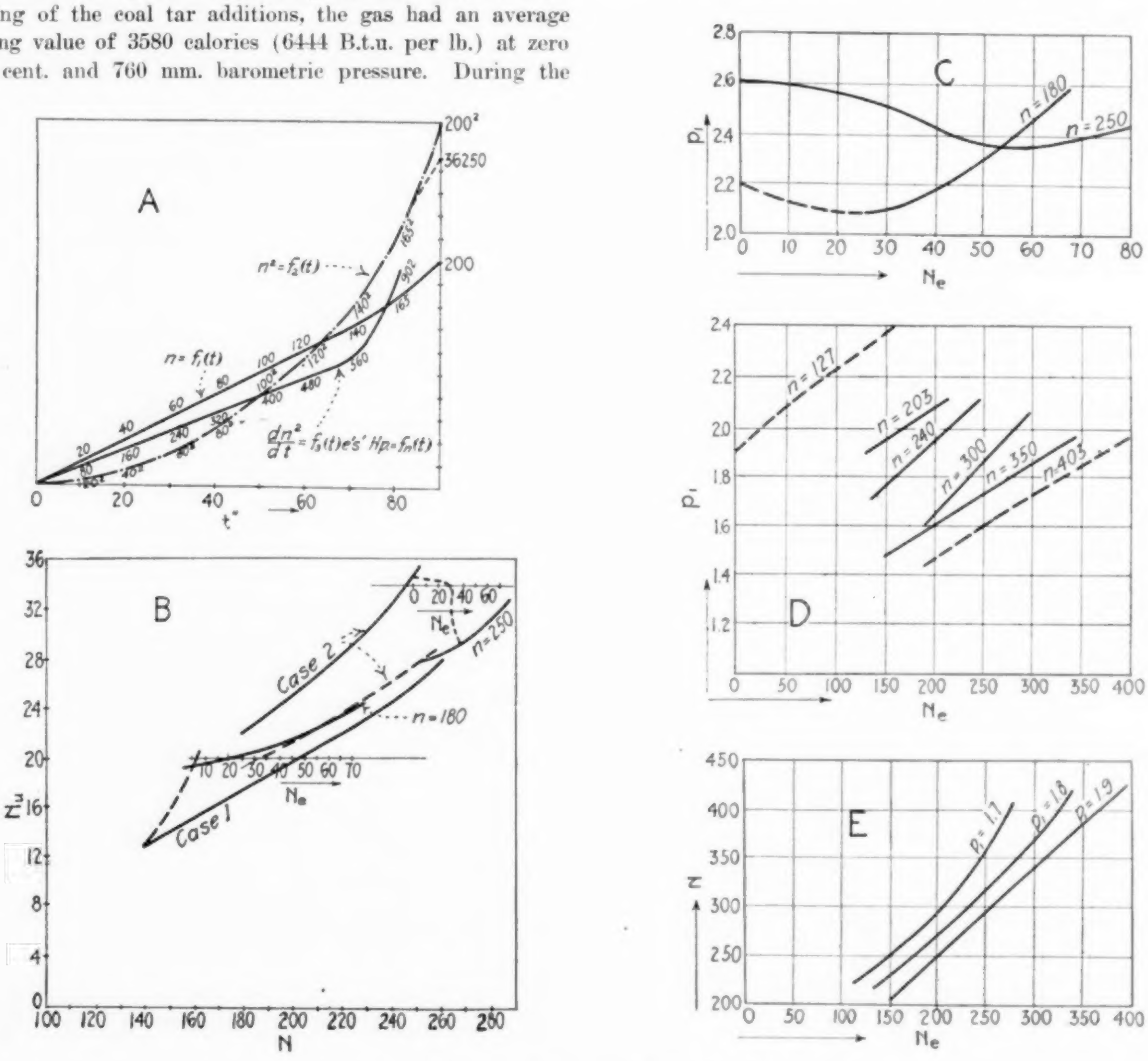

Fig. 1 Curves from Tests on Diesel Engines when Running Light

The no-load run proper is necessary to overcome all the internal resistances and depends, therefore, partly on the design and partly on the workmanship of the engine. The action of the flywheel has to be considered separately in this connection, as, because of air friction and windage, it often takes up quite a considerable amount of horse-power, increasing as the third power of the speed of rotation. With our present state of experimental information on this matter, it is difficult to determine analytically the amount of power consumed by a flywheel, while it is also difficult, if not impossible, to carry out a comparative test without a flywheel. If the speed of rotation is constant, the influence of the flywheel may naturally be neglected because the amount of work done by the flywheel can hardly vary; otherwise, the re-

sults obtained will be somewhat lacking in precision.

The experiments described below have been carried out on a single cylinder Diesel engine of 50 h.p., on which, by varying the speed, an output as high as 70 h.p. could be secured.

The moment of torsion is

$$M_d = Ip\frac{d\omega}{dt} = Ip\frac{\pi}{30}\cdot\frac{dn}{dt}\ldots\ldots\ldots\ldots\ldots\ldots\ldots[1]$$

where Ip is the polar moment of inertia of the flywheel in kgm. sec.^{2}, ω the angular velocity in sec.^{1}, and n the r.p.m.

TABLE 1 DIESEL ENGINE RUNNING AT LIGHT LOAD

A

t^{u}	n	$\frac{dn^2}{dt}$	$L\frac{\text{mkg}}{\text{sec}}$	PS
0	0	0	0	0
10	20	80	137.6	1.84
20	40	160	275	3.66
30	60	240	412.8	5.5
40	80	320	550.4	7.34
50	100	400	688	9.17
60	120	480	840	11
70	140	560	963	12.8
80	165	902	1551	20.6
90	200	2280	3870	51.6

B

Ne	pr	Nu
26.2	2.09	20.3
40.1	2.16	20.9
51	2.38	23
61.3	2.35	22.5
65	2.54	24.5
67.5	2.58	25.5

C

Ne	pr	Nu
0	2.62	34.8
24.1	2.55	34.2
42.5	2.2	29.3
60	2.34	31
70	2.4	32
80	2.44	33

of the engine. In order to produce this moment of torsion is required the work

$$L = Md\omega = \frac{9.86}{1800}\,Ip\,\frac{dn^2}{dt}\ldots\ldots\ldots\ldots\ldots\ldots\ldots[2]$$

and to calculate L, it is necessary to determine Ip and n as a function of time t. The value of Ip can be determined either experimentally or analytically, the latter being somewhat uncertain. In the present case, the analytically determined weight of the fly-wheel differed from that determined by actual weighing by 1.4 per cent, which tends to show that the mass used for the determination of I_p has been selected with sufficient precision to satisfy practical requirements. Such a calculation gave for I_p a value of 310 kg.m.sec.^{2}. $n = f_1(t)$ was determined experimentally. The power was shut off, the engine allowed to slow down freely and in 10 minutes the speed of rotation was read by a tachometer. The results obtained in this way are plotted in Fig. 1A as $n = f_1(t)$ (scale 1mm = 0.039 in. = 2 revolutions); $n^2 = f_2(t)$ is also plotted (scale 1mm = 0.039 in. = 250 n^2).

By graphic differentiation, the third curve

$\frac{dn^2}{dt} = f_3(t)$ was drawn to such a scale that 1mm = 10.

Equation [2] becomes in this case.

$$L = 1.72\frac{dn^2}{dt} \qquad [3]$$

The results thus obtained are presented in Table 1A, in which the last column gives the power consumption. The last series of figures in this table are not fully reliable, because an element of uncertainty crept into the construction of the tangent. These figures have been plotted on the diagram of Fig. B with the notation "Case I." This curve from $n = 140$ on has been plotted approximatively.

Tables B and C give the data of tests made on the same engine at constant speed: $n = 180$ r.p.m. and $n = 250$ r.p.m. In these tables Ne denotes the effective horse-power, Nu, the horse-power at no load, pr, the average pressure at no load in kg/cm^2 (1 kg/cm^2 = 14.22 lb. per sq. in.).

For plotting the curve, ("Case 2"), can be applied only a method in which interpolation is used, because with the present design of Diesel engine a "stationary" no-load operation is very difficult to obtain, and properly conducted tests at no-load always show a higher output of work than at load. By means of interpolation, however, from the actual no-load work can be obtained the "ideal," if, as shown in Fig. B, Nu be plotted as a function of Ne and the curve extended to $Ne = 0$. In this way the dotted curve for the "ideal" no-load work, ("Case 2"), is determined. The actual no-load curve lies above the dotted line and is shown for "Case 2" in full line. If it be desired to draw a comparison between no-load works at different speeds of rotation and at different loads, the indicated average pressure pr must be considered. In Fig. C, the values of pr given in Tables 2 and 3, are plotted as functions of the effective horse-power. This diagram shows that at high loads (that is, *not* at no-load) the indicated average pressure of no-load decreases as the speed of rotation increases. This is shown with particular clearness from Fig. D, representing the data obtained in the tests of Seyliger (*Zeits. des Vereines deutscher Ingenieure,* 1911, p. 587).

These tests are transferred also to Fig. E, where, as abscissae, are used the effective horse-power, and as ordinates, the speed of rotation, the values of pr being assumed respectively constant. These curves show at once that the no-load work, at the same effective load, does not increase in direct proportion to the speed of rotation, but remains somewhat below proportionality. Nevertheless, the mechanical efficiency for the same value of effective load must decrease with the speed of rotation. From Fig. E can be seen the values of pr and n for the effective load Ne = 225. Since, however, the indicated work is

$$Ni = C\,p^2\,n$$

where C is constant, and since it increases in the present case, notwithstanding the fact that Ne remains constant, it follows that, while the work increases, the mechanical efficiency decreases. If the speed of rotation increases, the in-

$$\begin{vmatrix} K_{11}+K_{12}-\alpha^2 & -K_{22} & 0 & 0 & 0 & 0 \\ -K_{12} & K_{22}+K_{23}-\alpha^2 & -K_{33} & 0 & 0 & 0 \\ 0 & -K_{23} & K_{33}+K_{34}-\alpha^2 & -K_{44} & 0 & 0 \\ 0 & 0 & -K_{34} & K_{44}+K_{45}-\alpha^2 & -K_{55} & 0 \end{vmatrix} = 0 \ldots\ldots\ldots [1]$$

dicated average frictional pressure decreases for the same value of Ne, which leads to a lower mechanical efficiency.

Attention must further be called to the fact that the larger the dimensions of the cylinders or the greater the units under investigation, the smaller becomes the value of pr. In practice, it has been found that in multicylinder motors, pr per cylinder decreases also.

Further, there must be taken into consideration, also, the influence of the air pump. In the above described tests, the air pump, which plays an important role in the determination of mechanical efficiency, has been taken into account because that corresponded to the actual conditions.

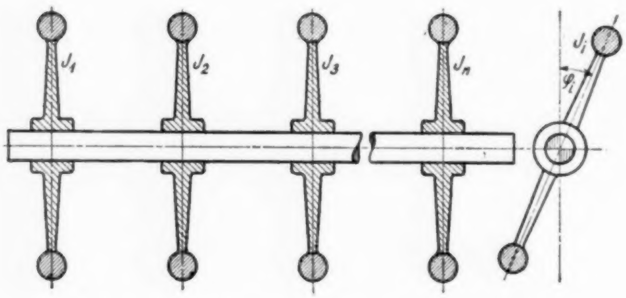

FIG. 2 TORSIONAL OSCILLATIONS OF A DIESEL ENGINE SHAFT

In order to draw comparisons, more precise investigations should be carried out, with and without counting the air pumps. Practically, however, this did not constitute any serious mistake, because the power consumption to the air pump in very large units is negligibly small as compared with the total output. (*Versuche über die Leerlaufarbeit von Dieselmotoren,* Arthur Balog, *Oel- und Gasmaschine,* vol. 15, no. 1, p. 1, April 1915, 4 pp., 7 figs. *et.*)

Mechanics

TORSIONAL OSCILLATIONS OF AN ENGINE SHAFT

The article is an investigation of the influence of torsional oscillations on the behavior of a Diesel engine shaft.

In the case of a Diesel engine which developed irregularities in action after passing a certain speed of rotation, it appeared likely that this irregularity may have been due to torsional oscillations. The shaft had four cranked members, a flywheel and, next to it, a dynamo. Therefore, apart from the mass of the shaft proper, these masses might have been taking part in the torsional oscillations; the moments of inertia of the flywheel and dynamo were, however, so much in excess of these others that they should have had a determining effect on the natural frequency of vibration of the shaft. At first glance, it did not seem possible to ascertain how great an influence was to be ascribed to the other masses and this necessitated an analytical method of calculation, which finally led to the method described in this article, permitting the determination of the influence of any number of masses on the vibration of the engine shaft.

Fig. 2 shows diagrammatically a shaft with a fairly large number of masses of which the moments of inertia about the axis of the shaft are indicated by $J_1, J_2 \ldots\ldots J_n$. The number and type of the bearings are not considered here because no attention is paid to the moments of friction; the air resistance exerted on the surface of the rotating masses is also left out of consideration. If a shaft develops free torsional oscillations, it is acted on by moments of torsion which vary by the amount $J_i \frac{d^2\phi_i}{dt^2} = J_i\phi_i$, only when the moment of inertia of a mass exceeds J_i and the instantaneous angle of torsion against the vertical (Fig. A) exceeds ϕ_i. The section of the shaft located between the i-th and the $(i+1)$th masses is twisted by the moment of torsion M_i through the angle ϕ_i for which case the relation $M_i = C_i\phi_i$ holds good.

By a process of mathematical analysis which has to be omitted here because of lack of space, the author arrives at the following two equations which fully determine the behavior of a shaft under conditions stated above:

and

$$\psi_i = \Sigma\, C_k\, \gamma_{ki} \sin\,(\alpha_k t - \delta_k)$$

$$[i = 1, 2, \ldots\ldots\ldots n-1;\ K = 1, 2, \ldots\ldots\ldots n-1]$$

where

$$\frac{C_1}{J_1} = K_{11};\ \ \frac{C_1}{J_2} = K_{12};\ \ \frac{C_2}{J_2} = K_{22}\ \ \text{etc.}$$

γ with its subscripts refer to constants depending for their magnitudes on the constants of the shaft and masses held on it. The difference of angles (cp. Fig. A) $\phi_2'' - \phi_1'' = \psi_1''$ and $\alpha = \frac{\psi_1''}{-\psi_1}$

[1] is an equation of the (n—1)th power for the (n—1) values of δ^2 which can be solved by any known analytical or graphical methods. When forced oscillations arise, one may expect as many resonances as there are values of δ^2. In most cases the minimum value of δ is of interest, and it can be usually determined approximately. This being done, the determinant of [1] is calculated with several values of δ near to the value found approximately (which is not difficult even with a large number of masses because of the many zeros in the determinant), and the values of the determinant are plotted on a system of coördinates as a function of δ^2. A curve through the points thus found gives a sufficiently close approximate value of δ.

Actually, because of the damping of oscillations, the greatest deflection will occur with the smallest δ, and even before that the deflections will become excessively large. Further, in order to avoid excessive vibrations, it is necessary to have the smallest periods of free oscillations considerably greater than those of the forced oscillations.

The following example shows the application of the above process. For the case discussed above, it is assumed that the oscillations are due mainly to the action of the flywheel and dynamo, here considered as masses 5 and 6 (the four cranked sections are denoted as 1 to 4). Then, from equation [1]

$$K_{55} + K_{56} - \delta^2 = 0,$$

or

$$\delta^2 = K_{55} + K_{56} = \frac{C_5}{J_5} + \frac{C_5}{J_6}$$

It was further found that for the flywheel $J_5 = 500{,}000$ kg/cm-sec.^{2}, and for the dynamo $J_6 = 36{,}000$ kg/cm-sec.^{2},

while C_5 (constant for the section of the shaft between flywheel and dynamo) is 1.68×10^5 kg/cm. Hence

$$\delta^2 = 5006 \text{ and } \delta = \pm 70.8$$

which corresponds to a speed of $\frac{70.8 \times 30}{\pi} = 677$ r.p.m.

The author shows further that the presence of the cranked portions of the shaft does not materially affect the oscillatory process.

Harmonic analysis of the tangential pressure diagram indicates that resonance is likely to occur only with moments of the second or fourth order. It was therefore to be expected that material oscillations would arise at speeds of $n = \frac{677}{2} = 339$ r.p.m., or $n = \frac{677}{4} = 169$ r.p.m. Actually, however, the speed of the engine, because of oscillations, could not be brought above 162 r.p.m. (*Torsionsschwingungen einer Dieselmotorwelle,* Otto Mies, *Dinglers polytechnisches Journal,* vol. 330, no. 6, p. 101, March 20, 1915, 3 pp., 1 fig. *tm.*)

Laws of Efflux of Drops from Capillary Orifices

In a previous note, the author has shown that the weight of drops escaping from a capillary orifice is a rather complicated function of the frequency of fall. As this frequency increases, the weight of the drops at first increases, passes through a maximum, and then decreases rather rapidly, being, however, at certain critical values of frequency subject to sudden increases so that at high velocities the weight of the drop may be substantially greater than that which it had when it passed through the first maximum.

The author made a series of tests with 15 tubes of different external and internal diameters, the internal diameters varying from 0.4 to 2.4 mm. and the external diameter from 2.3 to 7 mm. He expresses the results obtained in the following four laws:

First. The product of the internal diameter d by the interval of time between two drops T, corresponding to the first maximum is a constant A, or simple multiple of this number. From the frequency zero to that which corresponds to the first maximum, the weight of the drops varies nearly in a straight line with the frequency (after the passage of the first maximum the inverse variation becomes more rapid). This straight line as defined above determines, by extrapolation, the weight P_∞ corresponding to frequency O. This being so,

Second. Quotient of the increase of weight $\delta = P_m - P_\infty$ of the drop from the origin to the first maximum by the internal diameter d is a constant number B or a simple multiple of that number.

Third. A quotient of the weight P_∞ (at the origin) by the external diameter D is a constant number C. C is, however, different from B and in addition to that for tubes for a diameter in excess of 5 mm. it is different from that for tubes with a smaller diameter.

Fourth. From the instant of sudden increase of the

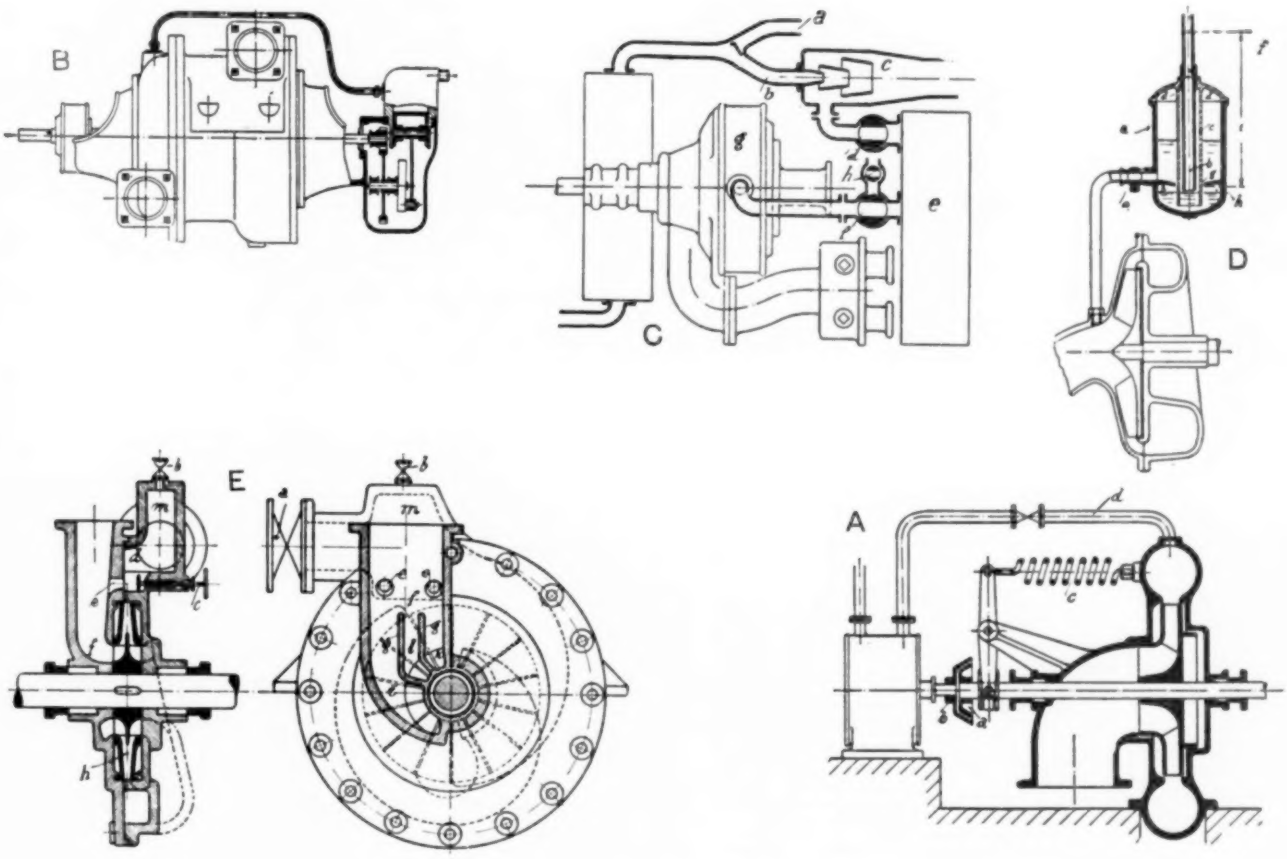

Fig. 3 Starting Devices for Fire Engine Centrifugal Pumps

weight of the drop, the quotient of this increase of weight or to a simple multiple of it. (*Sur les lois d'écoulement par gouttes par les orifices capillaires*, E. Vaillant, *Comptes rendus des Séances de l'Académie des Sciences*, vol. 160, no. 18, p. 596, May 3, 1915, 3 pp., *te.*)

Pumps

Centrifugal Pumps for Fire Engine Service

The article discusses the use of centrifugal pumps on fire engines, a test of such pumps carried out in the Berlin Fire Department Works, the priming of pumps by various means, and their designs.

In Berlin, two types of fire engine equipment are used—one storage battery driven and the other pure gasolene driven. During the recent tests of the storage battery driven engines, it happened that after the engine had been running for about 48 km. (29.8 miles), the current began to give out. The car was immediately shifted into a side street and the battery recharged right on the spot by a gasolene engine intended for driving the pump. For use in case of fire in suburbs, however, engines with a pure gasolene drive are used exclusively.

TABLE 2 VALUES OF c_p

pressure p / temperature of saturation t_s	0,5 at / 80,9° C	1 / 99,1	2 / 119,6	4 / 142,9	6 / 158,1	8 / 169,6	10 / 179,1	12 / 187,1	14 / 194,2	16 / 200,5	18 / 206,2	20 / 211,4
t_s	0.475	0,487	0,501	0,528	0,555	0,584	0,613	0,642	0,671	0,699	0,729	0,760
t = 110°	0,471	0,483	—	—	—	—	—	—	—	—	—	—
120	0,466	0,480	—	—	—	—	—	—	—	—	—	—
130	0,467	0,477	0,495	—	—	—	—	—	—	—	—	—
140	0,466	0,475	0,491	—	—	—	—	—	—	—	—	—
150	0,465	0,473	0,487	0,522	—	—	—	—	—	—	—	—
160	0,465	0,471	0,484	0,515	0,552	—	—	—	—	—	—	—
170	0,465	0,471	0,481	0,509	0,541	—	—	—	—	—	—	—
180	0,465	0,471	0,479	0,503	0,531	0,567	—	—	—	—	—	—
190	0.466	0,471	0,478	0,498	0,522	0,552	0,588	0,633	—	—	—	—
200	0,467	0,471	0,477	0,494	0,514	0,539	0,569	0,604	0,648	—	—	—
210	0,467	0,471	0,477	0,491	0,508	0,528	0,553	0,581	0,617	0,658	0,709	—
220	0,468	0,471	0,477	0,488	0,503	0,520	0,540	0,564	0,593	0,626	0,666	0,713
230	0,469	0,472	0,477	0,487	0,498	0,513	0.530	0,551	0,575	0,602	0,633	0,672
240	0,470	0,472	0,477	0,486	0,495	0,507	0,522	0,541	0,561	0,583	0,608	0,640
250	0,471	0,473	0,477	0,485	0,493	0,504	0,517	0,532	0,549	0,568	0,589	0,615
260	0,472	0,473	0,477	0,485	0,492	0,501	0,512	0,526	0,540	0,557	0,574	0,593
270	0,473	0,474	0,478	0,485	0,491	0 499	0,509	0,521	0,534	0,548	0,563	0,580
280	0,474	0,475	0,479	0,485	0,491	0,498	0,507	0,517	0,529	0,541	0,554	0,568
290	0,475	0,476	0,480	0,485	0,491	0,497	0,505	0,515	0,525	0,536	0,547	0,559
300	0,476	0,478	0,481	0,486	0,491	0,497	0,504	0,513	0,522	0,532	0,542	0,552
310	0,477	0,479	0,482	0,486	0,491	0,497	0,503	0,512	0,520	0,529	0,537	0,547
320	0,478	0,480	0,483	0,487	0,492	0,497	0,503	0,511	0,518	0,526	0,534	0,542
330	0,480	0,481	0,484	0,488	0,492	0,498	0,503	0,510	0,517	0,524	0,531	0,538
340	0,481	0,482	0,485	0,489	0,493	0,498	0,503	0,510	0,516	0,522	0,529	0,535
350	0,482	0,483	0,486	0,490	0,494	0,499	0,504	0,509	0,515	0,521	0,527	0,533
360	0,484	0,485	0,487	0,491	0,495	0,500	0,504	0,509	0,514	0,520	0,525	0,531
370	0,485	0,486	0,488	0,492	0,496	0,501	0,505	0,510	0,514	0,519	0,524	0,529
380	0,486	0,487	0 490	0,493	0,497	0,502	0,506	0,510	0,514	0,518	0,523	0,528

One of the difficulties to be overcome in the design of a centrifugal pump lies in the fact that the pump is not self-starting, and requires some auxiliary device either for creating a vacuum to raise the water from water level to the pump or for priming. This is done in several different ways; for example, German patent 263,112 employs a rotary air pump coupled directly to the shaft of the centrifugal pump and arranged in such a manner that, after the latter is filled with water, the air pump is automatically uncoupled from the centrifugal pump. As shown in Fig. 3A, on the prolongation of the shaft of the centrifugal pump is placed one-half, *a*, of a removable friction coupling, while the other half, *b*, is on the shaft of the air pump. When the aggregate is at rest, the air pump, because of the action of the spring *c*, is coupled with the centrifugal pump and the rotary part of the latter is displaced towards the suction side. If, however, the aggregate is started, the air pumped through pipe *d* sucks in the air in the centrifugal pump and in the suction piping, and thereby forces the water column to rise by suction. As soon, however, as the water has risen sufficiently, and the blade wheel is enabled to create a difference in pressure between the suction and pressure chambers, there is created an axial thrust on the blade wheel which forces it away from the air pump. The axial thrust is created through the difference in dimensions of the diameters of the lateral packing rings of the blade wheel. When the machine stops, the coupling of the air pump with the centrifugal pump is restored through the action of the spring.

In the estimation of the author considerable difficulty lies in the design of a suitable air pump. The so-called rotary pumps can be applied only with considerable difficulty because of the high speed used here in most cases. Besides, it is difficult to eliminate entirely the axial thrust, which is studiously avoided in all other types of centrifugal pumps. It appears, however, that good results were obtained with this arrangement at low speed, say, 600 r.p.m.

In the fire pump covered by the French patent 435,557 and shown in Fig. B, a special reciprocating pump is used for creating a vacuum in the centrifugal pump. The vacuum pump is built in directly on the centrifugal pump, and in the piping leading from the centrifugal pump to the air pump is placed a cock by means of which the air pump can be shut off from the centrifugal pump. Formerly, there was provided in the same piping a screen to prevent foreign bodies from entering the air pump; the latter is so built, however, that the water that may penetrate into it will do no harm. This pump was once used as an auxiliary pump in a water supply system, and it was found that the centrifugal pump ran for ten days against a suction head of 9 m. (26.2 ft.) without having once broken off the water column.

The German patent 200,765 (identical with the English patent 20,595) utilizes the suction of one or more cylinders of a multicylinder explosion motor for the priming of the centrifugal pump. The patent specifically provides for the interposition of a float in the connecting piping, whereby the entrance of water into the cylinder or cylinders of the motor is prevented. The float valve is arranged in such a manner that, as soon as the rise of water connects with the atmosphere, the further suction of water is stopped. If it proves possible to keep the water from the cylinders of the engine, the practical value of this invention is quite considerable; otherwise, it is of no value.

The French patent 429,270, belonging to the same English concern, utilizes for this purpose the arrangement shown in Fig. D. In the connecting piping is inserted a tank *a* filled up to a certain level with mercury. Around the pipe *b* reaching down into the mercury, is concentrically located the pipe *c*, the lower end of which is immersed in the mercury while the upper end is provided with openings, *d*. With

properly adjusted cocks e and f, the suction of the air pump forces the water into the tank a, delivers it through slot g into h and causes such a rise in the level of the mercury in pipe b that the opening of this pipe is cut off by the mercury. If the vacuum increases still more, the mercury rises to the level i, whereby the entrance of the water into the pump is cut off.

Of the several devices utilized for starting centrifugal pumps, the arrangement for maintaining a reserve of water on the pump shown in Fig. E is typical. (Patented in Germany, no. 255,461). Since the suction elbow of the centrifugal pump is directed upward, when the pump is stopped, it remains filled with water, and the pump should start when the cut-off valve a is closed, while the air cock b and valve c are open. In such a case, the water which collects in the pressure space d is led through the runner h, and along the ribs g, this taking place in such a manner that the two spaces i and k are filled with water while, in the middle space l, there occurs an injector-like action due to the fall of water. The mixture of water and air coming from the runner is led into the pressure space d, provided with an air reservoir m, and from d the air sucked in, is allowed to escape through the cock b. When water starts to come out from this cock, it shows that the pump is filled with water, then the cut-off valve a can be opened and the pump operated in the usual manner.

An interesting design (French patent 400,696) is shown in Fig. C, the fundamental principle of which is the use of the exhaust gases of an explosion motor driving the pump, to drive an ejector by means of which the pump is started. When the pump is to be started, the exhaust gases are delivered into the chamber through pipe b into the ejector c, not through pipe a. (Previous to that the cock d, which connects the close water tank with the ejector, has to be opened.) Because of the suction on the water, a vacuum is created in the tank e, and this, with cock f opened, results in water being sucked into the centrifugal pump g. By means of suitable adjustment of the cocks d, f and h, the suction into and the filling of the centrifugal pump can be regulated and the tank can be filled with, or emptied of, water. (*Kreiselpumpen für Feuerlöschzwecke*, Alfred Schacht, *Die Fördertechnik*, vol. 8, nos. 8 and 9, p. 57 and 67, April 15 and May 1, 1915, 8 pp., 14 figs., *d*).

Steam Engineering

Specific Heat of Superheated Steam at Pressures from 8 to 20 Atmospheres, and from Temperature of Saturation to 380 Deg. Cent.

For a considerable time, in the laboratory of Technical Physics, in Munich, extensive experiments on the determination of the specific heat of superheated steam have been carried on and gradually extended to cover the region of temperatures up to 550 deg. cent. Recently a boiler became available for use in the laboratory, admitting pressures up to 30 atmospheres gage, which made it possible to enlarge the region of experimentation up to that pressure.

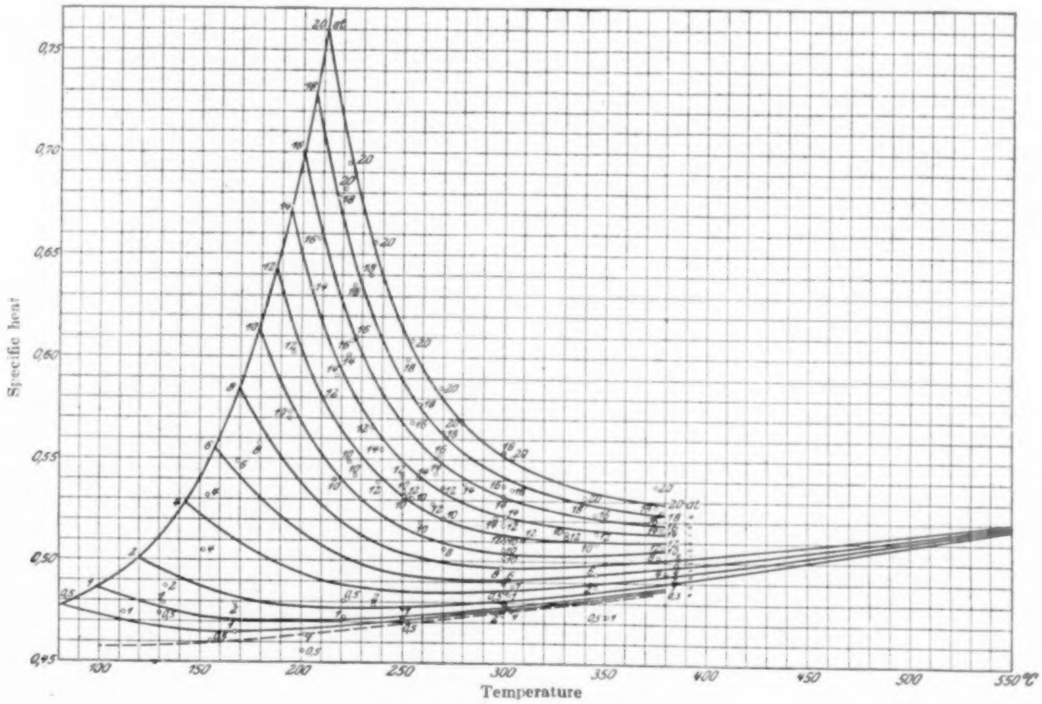

FIG. 4 c_p ISOBARS IN THE c_p t DIAGRAM

The formula for c_p is derived in the following manner: Mollier derived for the heat of generation of steam i (that is, heat, in kcal., which must be supplied to 1 kg. of steam at 0 deg. cent, to convert it, without altering the pressure, into 1 kg. of steam at t deg. cent. and p kg. per sq. cm. pressure) the following formula:

$$i = 594.735 + 0.477\,t - J_p$$

where J is a function of t only, and Mollier gives its numerical values in a table. The small fall-off in pressure Δ_p

corresponding to a small increase in the heat of generation of steam Δi is therefore approximately $\Delta i = J\Delta_p$, and since this amount of energy has been taken from a source of electrical heat at the point of the experimental apparatus denoted as u, the amount available there for the superheating of the steam becomes $[(W - V) - GJ\Delta_p]$ where W is the total amount of electrical energy shown by the meter, V heat losses, and G weight of steam flowing through per hour. This gives for c_p, the following expression:

$$c_p = \left[\frac{W - V}{G} - J\Delta_p\right]\frac{1}{t_2 - t_1}$$

The original article contains a table (Table 2) of values of specific heats calculated by means of the above equation. In Fig. 4 these values of c_p have been plotted as ordinates over temperatures, as abscissae, and curves have been drawn through them connecting points of equal pressure. In plotting these c_p-isobars, drawn for 0.5, 1, 2,.... 20 atmospheres certain methods of equalization had to be resorted to, in addition to which the behavior of c_p at the critical point, and the dependence of the total heat i on pressure had to be considered. At the critical point, c_p must become infinitely great. Hence, if all the c_p-isobars be extended to the left to the point of saturation, and the terminal points be connected by a curve, this c_p-saturation curve will reach at the critical point the value $c_p = \infty$.

The total heat i (which has to be supplied to 1 kg. of water at 0 deg. cent., to convert it at the same pressure into steam of a given temperature) is, at a given temperature, greater for lower pressures than for higher ones. The c_p-isobars therefore have to be drawn in such a manner that they give for i values which satisfy this dependence on pressure.

In Fig. 4 is shown, dotted, also the curve obtained by extrapolation for zero atmospheres.

The comparison of these isobars with those of Knoblauch and Mollier for 2, 4, 6 and 8 atmospheres indicates, in the region of superheat, only very slight differences, but on the saturation line the values have to be lowered considerably as compared with the former ones, in order to bring them into accord with those determined at higher pressures.

The author compares his results with those of M. Jakob (*Zeits. des Vereines deutscher Ingenieure,* 1912, p. 1980) and G. A. Goodenough (Trans. A. S. M. E., vol. 34, p. 507), who both start with the Clausius thermodynamic equation, with the difference, however, that Jakob determines c_p from v while Goodenough attempts to do the reverse.

Jakob used an equation of state of steam derived from the determinations of Knoblauch-Linde-Klebe, and, within the region of validity of this equation finds, between values of v calculated from the equation and those determined by measurement, differences below 0.25 per cent, a truly excellent agreement. But at higher pressures in the region of superheat, the deviations of the values of v as determined by the Clausius formula from those found by observation, are much greater, and the difference at 19 atmospheres and 300 deg. cent. amounts to 1.1 per cent.

The agreement between the measured values and those calculated by the Goodenough equation is naturally less close, because, as has been shown in technical literature, the double differentiation in t, required in the Clausius formula to determine c_p from v, changes very materially the value of c_p even when the error in the value of v has been very slight. Nevertheless, up to 8 atmospheres and 550 deg. cent., the values from the Goodenough equation differ from those found by the author, by less than 1 per cent, but gradually become less as the region of saturation is approached. For average and high superheats, however, the differences between the calculated (from the Goodenough equation) and observed values is not great even for higher pressures, and, e.g., at 20 atmospheres and 350 deg. cent., reaches only 2.5 per cent, the calculated values being the smaller ones.

The authors believe that a slight variation of the Goodenough equation or constants used in it might give as good an agreement for the higher pressures as for pressures up to 8 atmospheres. It is surprising that, notwithstanding the inherent lack of precision in the process of determining c_p from v, the Goodenough equation gives results in such a close agreement with observed values.

The authors believe that what has been found in the case of steam as to the dependence of specific heat on pressure and temperature applies also to other gases of which the molecules consist of several atoms. As a matter of fact, Scheel and Heuse have already found, in the case of atmospheric air in the neighborhood of its point of condensation, that c_p increases as the temperature goes down. (*Die spezifische Wärme c_p des überhitzten Wasserdampfes für Drücke von 8 bis 20 at und von Sättigungstemperatur bis 380° C.*, O. Knoblauch and A. Winkhaus, *Zeits. des Vereines deutscher Ingenieure,* vol. 59, nos. 19 and 20, pp. 376 and 400, May 8 and 15, 1915, 9 pp., 7 figs. *etA.*)

Boiler Accidents in France in 1912

The table below is taken from a compilation from official reports on boiler accidents. The data are tabulated, and give: date of accident; kind and location of plant in which it occurred; kind of apparatus; brief statement of circumstances; number of killed and wounded; supposed cause of accident.

Table 3 is a resume of these data.

(*Bulletin des accidents d'appareils à vapeur survenus pendant l'année 1912. Annales des Ponts et Chaussées,* vol. 24, ser. 9, no. 6, Technical part, p. 626, November-December 1914, 16 pp., *sd.*)

TABLE 3. BOILER ACCIDENTS IN FRANCE IN 1912

Kind of apparatus:	Number of accidents:
Not-tubular (tank) boilers:	
(a) external furnace, horizontal	5
(b) internal furnace, vertical	1
Fire-tube boilers:	
external furnace, semi-tubular	1
internal furnace, direct fired	2
internal furnace, return fired	2
Water tube boilers	7
Superheater	1
Thermosyphon	1
Water-gage glass	2
Blow-off cock	1
Safety valve	1
Vessels	4
SUPPOSED CAUSES OF THE ACCIDENTS	
Lack of care in the riveting of the shell case	1
Defective manufacture of tubes in semitubular boilers	1

Lack of tightness in covers	4
Defective welding:	
of superheater case	1
of steam collector	1
Old age, corrosions	4
Splitting of rivet holes	1
Overheating due to scale	3
Excessive pressure due to clogging of valve passages	1
Overheating to lack of water	2
Overheating due to unknown causes	1
Excessive pressure	1
Improper management and attendance	3
Breakage of water gage glass	2
Breakage of the case of the blow-off valve	1
Lack of strength in locomotive boiler	1

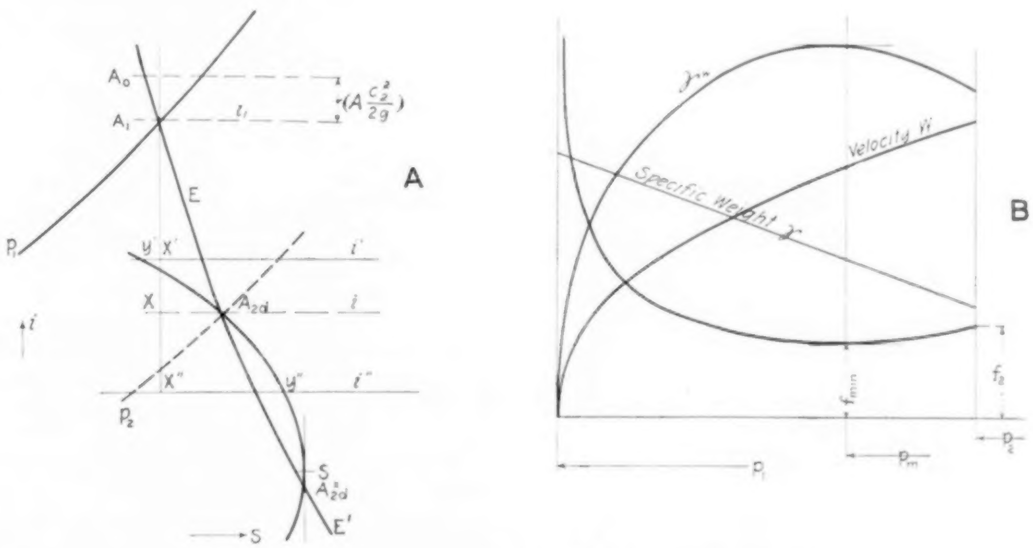

FIG. 5 CURVES OF PRESSURE VARIATION IN STEAM TURBINE AND NOZZLES

DETERMINATION OF PRESSURE VARIATION IN STEAM TURBINES AND OF DIMENSIONS OF NOZZLES BY MEANS OF THE JS DIAGRAM

The present article is an abstract from a book published by Doctor G. Zerkowitz, under the title "Thermo Dynamics on Turbo Machinery" (Thermodynamik der Turbomaschinen).

The author, who uses the JS diagram of Mollier, denotes his process as a method of geometric loci, since for the determination of the state of steam at any point in the turbine, he draws on his diagram two curves, one of which satisfies the condition of continuity, while the other contains all the points corresponding to the equation of energy: $A\frac{c^2}{2g} = i_1 - i_2$ where A is the mechanical equivalent of heat, c velocity, g coefficient of acceleration or free fall, and i_1 and i_2, the heat contents at two different points of the stream of steam. The point of intersection of these two geometric loci represents the point of state sought for.

The determination of the state of the steam when it leaves the distributor may be used as an example. Under the assumption that the weight of the steam G, flowing through per unit of time, is given, it is possible, when the shape of the blade is likewise given and its cross-section f is known, to determine for every point the value of the right side of the equation of continuity $\frac{G}{f} = \frac{c}{v}$ where G is the weight of steam per second, f cross-section of flow, v specific volume and c velocity. If it be further assumed that the initial state of the steam expanding in the diaphragm is known, then the velocity c, at any point of heat content i, can be determined from the difference in temperature. If this value be inserted on the right side of the equation of continuity, it serves to determine the specific volume v at that place. It is now possible to determine by means of the curves of equal volume in the JS diagram, on the horizontal line characterizing the heat content i, a point for which the specific volume is v.

If the same process be repeated under the assumption of different heat contents and the points corresponding to different specific volumes v be connected with each other, then, as Fig. 5A shows, there will be obtained a line curve Y′ Y″, which satisfies the equation of continuity. Further, assuming a certain loss of energy in the blading, the process of expansion may be represented by a curve E E′, which corresponds to the equation of energy. The point of intersection A_{2d} of these two curves satisfies both conditions and characterizes the state of the steam after it leaves the distributor. If A_1 denotes the state in front of the distributor and use is made of the velocity of outflow in the preceding stage, then the fall in heat corresponding to this velocity is plotted from A_1 up to A_0, and the fall A_0X is used as a basis for the calculation of c. The second point of intersection A^x_{2d} of the geometric loci is determined for turbines having a velocity in excess of that of sound, while the point S at which the tangent of the Y curve is vertical denotes the entrance of adiabatic velocity of sound.

The determination of the process of variation of pressure is of practical value in the investigation of the governing of turbines. If, however, for example, p_m denotes the pressure in front of the m-th stage at full load, $pm + 1$ the pressure in front of the $(m + 1)$the stage under the same con-

ditions, while $p'm$ and $p'm + 1$ denote pressure at part load, then it can be often shown that $\frac{pm + 1}{pm} = \frac{p'm + 1}{p'm}$. Therefore the velocities of outflow in the separate stages are constant. If such is not the case, then the efficiency varies; and also the ratio of peripheral speed to the velocity of steam may deviate more or less from the most advantageous line.

For the graphical calculation of nozzles, the JS diagram may be also used to advantage. For the solution of this problem, a curve of state is used which diverts from the vertical adiabate to the right; then the pressures p are plotted, which can be found from the diagram and correspond to single points (Fig. B). These pressures are plotted

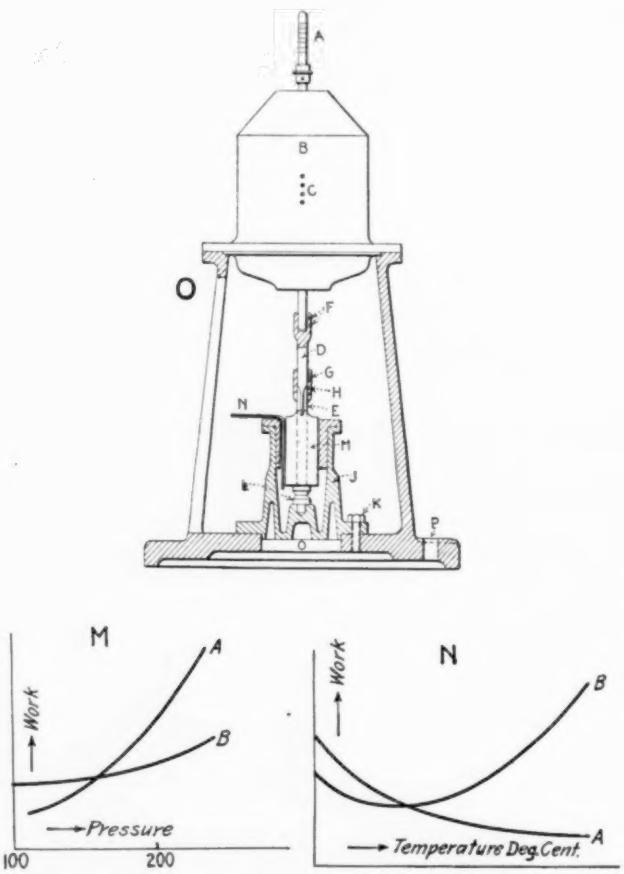

FIG. 6 KAPFF OIL TESTING MACHINE AND CURVES OF TESTS OF OILS

as abscissa, and over them are plotted as ordinates, the specific weights γ, as well as the velocities w, which can be read off on a scale on the side of the Mollier table. Likewise as ordinates the values of the product γw are plotted and then, by means of the equation of continuity, the cross-sections f are calculated and plotted on the diagram.

For practical purposes it is sufficient to determine by the formula the critical pressure; then the smallest cross-section and finally, under the assumption of expansion to any desired counter pressure, the cross-section of the outflow. (*Berechnung des Druckverlaufs in einer Dampfturbine sowie der Düsenabmessungen mit Hilfe des JS-Diagramms*, Schmolke, *Dinglers polytechnisches Journal*, vol. 330, no. 8, p. 152, April 17, 1915, 2 pp., 2 figs. *t.*)

Testing Machinery

PROFESSOR VON KAPFF'S OIL TESTING MACHINE

This paper describes the oil testing machine designed by A. von Kapff. While this machine is not new, it is described in detail because it is not mentioned in such works in the English language as "Lubrication and Lubricants," by L. Archbutt and R. Mountford Deeley (London 1912), and "Lubricating Oils, Fats and Greases," by George H. Hurst (London 1911).

The properties of a lubricant essential for the determination of its lubricating value are its cohesion and adhesion. Cohesion, sometimes also denoted as viscosity, is the internal friction of the oil and the thicker the oil, the more work is necessary to overcome this. On the other hand, the ability of the lubricant to maintain a film of oil between the surfaces in friction and thus prevent their seizing and overheating, depends upon the adhesion of the oil. The greater the pressure between the surfaces in friction the greater must be this adhesion, since otherwise the oil would be forced from between the surfaces.

As a rule, in a lubricant adhesion and cohesion go together; that is, when the oil holds well between the surfaces in friction, high internal friction goes with it. In oils of equal cohesion, however, the adhesion may be quite different, and vice versa. Therefore, the determination of the internal friction, which is the only thing that can be made by means of a viscosimeter, gives only a very rough idea of adhesion and value of lubricant as compared with other oils in reduction of power consumption. It is only by means of a regular oil testing machine that this can be done and, for e ample, the two diagrams, Fig. 6 M and N, show to what degree the action of oils depends on temperature and pressure. The oil A, Fig. M, consumes at low pressure less power than oil B and is therefore more suitable for the lubrication of spindles or bearings under low pressure, while B is more adapted for high pressure bearings. Fig. N shows two kinds of cylinder oils, A, maintaining its lubricating properties at high temperature while B loses its lubricity at about 170 deg. cent. (338 deg. fahr.). Therefore, the fuel consumption and oil consumption with B is considerably greater than with A.

The oil testing machine of Professor von Kapff is shown in Fig. O, where A is a speed counter set on the motor axis, consisting of a glass tube, graduated and partly filled with liquid. As the speed increases, the air bubble in the tube comes down, thus indicating the speed. Experience has shown that the best comparable results obtained at speeds varying between 3000 and 7000 revolutions, while spindle oils can be tested at 6000 to 7000 revolutions. The speed is adjusted first by the heavier rheostat G and then by a finer rheostat F, actually located on the switchboard. When two oils are tested for purposes of comparison, the speed, temperature and pressure should naturally be the same. When the speed counter is taken off and then put on again, it is important to set it centrally.

In Fig. O B indicates the housing for the electric motor; C are for terminals connected with similar terminals on the switchboard; D is the connecting link between the axis of the motor and the friction spindle E, rigidly connected with the motor shaft by means of an adjusting screw F (this F, and the following G, are different from similar letters used by the author to denote the rheostats). Over the upper part of the friction spindle (fork shaped) is set a bush H, likewise

provided with an adjusting screw G. When the oil tank J is either taken out or put in again, the screw G is screwed in hard, H lifted up and then screw G loosened. When the tank is set right so that the mark I coincides on the casing with the mark made at the foot of the tank, the screw G is again loosened, H set over the upper part of the spindle and screw G driven in hard once more. The screws K connect the tank rigidly and centrally with the casing. L a thrust journal upon which the spindle runs. The pressure is provided by a separate pressure element M, on the upper part of which is located the loading lever not shown in the drawing, N is a thermometer inserted through an opening on top of the tank into the oil. (In Fig. 6 the thermometer is shown bent, but it may also be straight.)

For spindles and transmission, oils are used with temperatures from 20 or 60 to 100 deg. cent. (68 or 140 to 212 deg. fahr.); for cylinder oils, temperatures from 100 to 350 deg. cent. (212 to 662 deg. fahr.). The tank J is filled nearly up to the edge with the oil to be tested. When the oil has to be changed the tank is emptied, washed with kerosene and then with gasoline. For heating the oil in the casing, an opening O is provided under which a good Bunsen burner may be placed.

Before the current is turned on and the motor started, it is well to bring the oil up to approximately the desired temperature; then the speed of rotation is regulated by means of the rheostat until the voltmeter and ammeter have remained stationary for some minutes at the desired temperature and speed of rotation. For regulating the pressure, two weights are provided. Spindle oils and light bearing oils are tested at pressures of about 2 or 3 kg. (28.44 to 42.66 lb. per sq. in.); transmission oils at about 10 to 20 kg. (142.2 to 84.4 lb. per sq. in.) and cylinder oils at 5 to 10 kg. (71.1 to 142.2 lb. per sq. in.). If at a given pressure the apparatus runs irregularly,—that is, if the speed and power consumption vary by jumps,—it shows that for the given oil the pressure is too high. The speed of rotation of the motor should be clockwise when looked at from above. The apparatus is arranged to run on 110 or 220 volts, d.c., and consumes about 1/3 h.p. (*Oelprüfungsmaschine von Prof. von Kapff, Petroleum,* Vol. 10, no. 14, p. 543, April 21, 1915, 3 pp., 4 figs. *d.*)

ENGINEERING SOCIETIES

AMERICAN INSTITUTE OF MINING ENGINEERS

Bulletin, no. 102, June 1915, New York City

Modern Gas-Power Blower Stations, Arthur West (abstracted).
Fire-Fighting Methods at the Mountain View Mine, Butte, Mont., C. L. Berrien.
Conversion Scale for Centigrade and Fahrenheit Temperatures, Hugh P. Tiemann.

Modern Gas-Power Blower Stations, Arthur West.

The paper describes briefly some recent large blower installations for blast furnaces where the blast is supplied exclusively by gas engines using furnace gas. The following installations are described: Bethlehem Steel Company, eleven engines; Minnesota Steel Company, at Duluth, five engines; Maryland Steel Company, at Sparrows Point, five engines.

The most recent of all of these installations is that of the Maryland Steel Company, and it presents several unusual features. In the first place, although the engines are the same size as those at the Bethlehem and Duluth plants, they are set diagonally in the house, which gives more room around them with the powerhouse 20 ft. narrower. The length of the house is not increased, both because the outboard bearings over-lap each other and because there is room left in the triangular space at the end of the station for a railroad car to enter under the traveling crane, but with engines set squarely across the house at least one extra panel must be provided to allow the entrance of such a car. Because of the lesser span, the costs of both the roof trusses and the traveling crane are likewise reduced.

The arrangement is such that, without moving from the front of the gage board, one man can, single handed, put two engines on the furnace very quickly. The operations are stated as follows: open cold blast valve, (operated by compressed air, controlled from in front of the gage board) to proper furnace, thus letting the blast pressure directly upon the Dyblie automatic check valve on top of the tub; second, by same means, open air snorting valve at side of tub; third, open jacket water valve; fourth, throw in igniter switch; fifth, open gas throttle; sixth, open valve supplying compressed air for starting gas engine. The engine will immediately pick up speed and run under the control of the governor, the tub discharging its air through the snorter out of doors, the Dyblie valve remaining seated under the blast pressure; then, seventh, by means of compressed air, close the snorting valve and the Dyblie valve automatically opens wide and the engine is blowing the furnace. The engine being at all times under the control of the governor, its speed does not vary when it is put on the furnace. It can be put on a furnace very rapidly, always in less than one minute, and the author states that he has seen it done in 35 seconds, with the engine absolutely cold.

It is highly important that the air should be measured into the furnace as carefully and as uniformly as the ore, coke and limestone. A good modern blowing tub with automatic valves is the best known means of measuring air outside a holder. With properly designed air valves, leakage is infrequent, but if there is leakage, it can be easily detected and remedied. The weight of the air delivered to the furnace per minute must remain constant no matter what the variation in the blast pressure. This requires that the engine have tubs designed with the utmost care and that it be equipped with very sensitive speed governors. Sensitive recording speed charts are also installed.

One of the novelties in the design of the plant is that, contrary to the usual practice, the Theisen gas washers have been located directly in the engine room, the idea being that since economical operation of the gas engine is dependent upon the cleanliness of the gas, the chief engineer of the power house ought to be directly in charge of the gas-cleaning apparatus. This arrangement has proved very successful at the Maryland plant. It required only the addition of one bay to the length of the station and saved nearly the whole first cost of the Theisen washers, with its traveling crane, etc. (9 pp., 7 figs., *l*)

AMERICAN SOCIETY OF CIVIL ENGINEERS

Proceedings, vol. 41, no. 5, May 1915, New York City

The Twelfth Street Trafficway Viaduct, Kansas City, Missouri, E. E. Howard
The Picaza Bridge, A. A. Agramonte
Pearl Harbor Dry Dock, H. R. Stanford (abstracted)
The Burden Water-Wheel, F. R. I. Sweeny

Pearl Harbor Dry Dock, H. R. Stanford.

The paper describes in considerable detail the construction of the Pearl Harbor dry docks. Among other things,

the author discusses the concrete used in that construction and describes tests made on them. Only this part of the paper is here abstracted.

Numerous experiments were made to determine the mixture which would produce the most dense and plastic concrete. The ingredients in each mixing were carefully weighed, then mixed with shovels and placed in an 8-in. pipe closed at one end, to determine the volume of the mixture. The degree of density was obtained by comparing the volume with the weight. The plasticity was determined by observing the action of the concrete when handled with shovels and by the settlement into the mass of two wooden rods having sectional areas of 1 and 2½ sq. in. respectively, under the weight of a man.

It was found that, other conditions being the same, the concrete made with the 1 in. stone was more dense and plastic than that obtained with the larger stone. Graded stone, containing such percentages of each size that when plotted it gave a straight line, produced concrete which was at the same time most dense and plastic. An excess in the percentage of small pieces increased the plasticity but decreased the density, whereas a deficiency in the smaller sizes had little effect on the density but reduced the plasticity. Mixtures in proportion of 1:2.5:4 were more plastic than 1:2:4 but not as dense; 1:2:4 mixtures were more dense than those of 1:2:3.5 but not as plastic.

TABLE 4 RESULTS OF CRUSHING TESTS

Class	Sand	Age	Crushing Strength in Pounds per Square Inch	
			In Salt Water	In Fresh Water
I	Three parts screenings passing 1/8-in. mesh with dust retained on 30-mesh, with 1 part Puget Sound sand......	3 days	685	620
		28 days	1 435	1 320
		2½ mos.	1 860	2 285
II	Screenings passing 3/16-in. mesh with dust retained on 30-mesh..........	3 days	590	470
		28 days	1 280	1 230
		3 mos.	1 985	1 985
III	Screenings passing 3/16-in. mesh containing all the dust of fracture.....	3 days	630	565
		28 days	1 505	1 390
		3 mos.	2 655	2 370
IV	Sand from Puget Sound............	3 days	905	845
		28 days	1 745	1 780
		2½ mos.	2 450	2 360

A series of 132 laboratory crushing tests were made on 6 in. tubes. Nine sets of 12 blocks were made of concrete mixed in proportions of 1:2:3.5, using for each test uniformly graded stones not larger than 1 in. but with differently mixed cr prepared sands for the different tests. The results are given in Table 4.

In addition to that, fifteen large-sized test blocks were made under conditions which resembled those actually existing when placing under-water concrete for the bottom of the dock. The concrete for these tests was deposited with tremies in water about 52 ft. deep, the end of the tremie being held near one corner of the form, so that the concrete had to flow an extreme distance of about 6 ft. after leaving the tremie.

A great deal of interesting experience in the use of tremies has been acquired in handling a product at first practically worthless, and then gradually improved until it finally attained a high degree of excellence. Tremies 12 in., 15 in. and 18 in. in diameter were used in these experiments (approximately 14,840 cu. yd. of concrete were deposited through tremies), and the author arrived at the following conclusions:

The results obtained from a tremie depend to a great extent on the proportions, character of materials and plasticity of the concrete which is being used; the excessive frictional resistance to the movement of concrete in a 12 in. pipe causes frequent clogging in the pipe and gradually increases the pressure at the exit, making it impracticable to hold the end of the tremie embedded in the deposited concrete; the frictional resistance to the movement of concrete in an 18 in. pipe is not sufficient to prevent the occasional loss of a charge in the tremie, thereby interrupting the filling of the form, with added uncertainty as to the quality of the product; the frictional resistance in a 15 in. tremie is apparently just about right to obtain the proper discharge pressure necessary for efficiently regulating the flow of concrete by raising and lowering the tremie with the end maintained within the deposited mass. The concrete flows freely to distant parts of the form without causing disturbance in the mass. The tremie 15 in. in diameter is best suited for the work, and in the Pearl Harbor dry dock construction the size was adopted and actually used for placing the greater part of the tremie concrete.

Approved designs, however, eliminated practically all tremie-placed concrete, without involving endangering conditions. This fact is considered a most valuable feature of the plan of construction, inasmuch as there can be no absolute certainty that concrete deposited under water will possess the uniform degree of perfection essential to dock construction. 72 pp., 19 figs. and 25 plates, *de.*)

CLEVELAND ENGINEERING SOCIETY

Journal, vol. 7, no. 6, May 1915, Cleveland, O.

SOME MACHINE-TOOL DEVELOPMENTS OF 1914, L. P. Alford

The paper presents a very interesting record of the development of machine shop equipment during 1914, from information previously published in *The American Machinist*, of which the author is the editor. The paper cannot be fully abstracted owing to lack of space, and only the most prominent sections are here reported.

One of the questions which the author takes up is whether new machines should be introduced in dull times. On the one hand, there is the desire to stimulate business by offering something new, and the desire to use shop effort, released from the strain of regular production, in developing new ideas. On the other hand, however, the machine tool business is so firmly established on sound engineering principles and firm industrial bases that there is only a very remote possibility that any builder can endanger his competitor's business through the discovery and control of some startling or revolutionary innovation. No manufacturer need fear for his stock because of the new designs of his competitors, but in the introduction of a new design by the manufacturer himself, there is a possibility of dangerous reaction on his own stock in that he can seriously destroy its salability by

bringing out such improvements. In other words, a manufacturer can easily become his own worst competitor. The conclusion is, therefore, that improvements should be brought out when stock is low and that means, in boom times. As one of the speakers (H. M. Lucas) stated in the discussion which followed, "It is well to work out new designs during the dull times, but do not announce them until you get your old stock all sold. Manufacturers usually announce their new designs too soon."

The question of high speed drilling is discussed in detail. Last year, some sensitive drilling machines were put on the market, having spindle speeds as high as 10,000 r.p.m., although experimentally, drilling has been done with speeds up to 20,000 r.p.m. In the larger sizes of machines, 1 in. drills have been successfully run on tests at a speed of 12,000 r.p.m. and a feed of 1 in. per second in cast iron. (The author has seen these tests.)

In high speed drilling with numbered sizes of drills it has been found that the limit of the rate of speed is the muscular activity of the operator. Once the drill has entered, it can be pushed through as rapidly as the operator chooses to move his arm. The tendency of power feeds is toward still higher speeds for small drills than can be obtained by hand, and while the limit of speed has been frequently reached with sewing and shoemaking machines, due to lack of quickness in the operator, with machine tools the operator has always been able to keep up easily with the machine. It appears reasonable, therefore, to expect that the commonly used speeds for drilling and feeds of small drills will be greatly increased within the next few years.

The author discusses in detail the possible limitations in drilling practice. Of these, it appears that the wear of the drill is little affected, in the end, by the speed. The cutting edges of the drill are rather preserved than otherwise, at the higher speeds. As regards heating effects, it is claimed that the total heating effect at high speed is less destructive to drills than at slower speeds. The stresses on the drills are less, the drill is advancing rapidly into the cold metal and as the period of drilling an individual hole is short, the proportion of time that the drill is in the air to the time that it is cutting is increased. It appears, also, that at high speed drilling, less heat will be given to the tool by the chips than at low speed drilling. This is due to a hitherto unexplained fact, namely, that when the chips break off, they are cold and uncolored, but become hot and colored a few seconds later. This action has also been observed in milling and turning.

Increased speed of drilling makes it more important than ever that jigs and work-holding devices should be so designed that they can be rapidly operated. This may mean the use of cams, eccentrics or levers, which are more quickly locked and unlocked than strap and screw-operated devices. Further, increased production means an increase in the rapidity with which chips are produced and jigs must be so made that the chips can be easily brushed or washed away.

The year 1914 has seen the introduction of a system of applying a large amount of lubricant to milling cutters mounted in a rigid machine, whereby peripheral cutting speeds on mild steel ten to twelve times greater than accepted practice (800 ft. per min.) were attained in tests of long duration, with a possible increase in the amount of feed from 30 to 112 in. per min. This system, because of the large amount of lubrication used, has become known as "stream lubrication." Its use is based upon the fact that the heating of the cutter is often *the limitation* to speed, and this can be reduced by using a lubricant or coolant sufficient to remove the heat and keep the cutter and the work cool.

One of the advantages of high speed milling is that it brings the revolution marks closer together, and it is claimed that miller outputs are controlled to-day, in perhaps 90 per cent of cases, by the distance between the revolution marks.

The past year has also played an important part in the development of the so-called "station type" machine, which means a machine in which there is a position for putting in and taking out work and other positions for performing successive operations. While as a tool, it is not new and many machines of this type have been built for special jobs, it was only in 1914 that these machines were brought out for the market in a form to be used on many jobs adapted for a wide variety of work. The needs of the automobile industry have been a feature in developing this line. They have been designed to fulfil the demand for quantity machinery manufacture with unskilled workmen and to make possible an increase of production with a decrease in the accompanying overhead expense.

The main trends of machine tool development in 1914 are summarized by the author as follows: They are toward the use of higher speeds, finer unit feeds, and greater quantities of lubricants; the further development of jigs, fixtures and holding devices which may be operated in a minimum time and the use of highly organized automatic machines, performing a number of successive operations, and suitable to be attended by unskilled labor. (27 pp., 14 figs. *dA.*)

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Proceedings, vol. 31, no. 3, April 1915, Pittsburgh, Pa.

Consideration with Regard to the Rapid Transit Problem in Cities, George F. Swain

The Electric Furnace for Re-Heating, Heat Treating and Annealing, T. F. Baily (abstracted)

The Electric Furnace for Re-Heating, Heat Treating and Annealing, T. F. Baily

The paper discusses the use of electric furnaces for reheating, heat treating and annealing, both historically and practically.

The type of furnace apparently best adapted for reheating operations is the resistance type in which the material to be heated is entirely separate from and independent of the resistance element in which the heat is generated by the electric current, making it extremely simple and convenient to operate. In some heating operations, the actual cost of heating per ton is less with the electric furnace than with combustion furnaces, while in some heat treating and annealing operations, the precision with which the operations are carried out must be the justification for the higher cost of heating in the electric furnaces. In a general way, it is stated that the higher the temperature at which the heating operation is conducted, the higher the relative economy in the use of electric furnaces. The author sums up the principal advantages of electric furnaces for reheating, as follows: More accurate temperature control; non-oxidizing atmosphere; saving in space; elimination of blast and stack; evenness of temperature throughout the heating space; simplicity of control; smaller amount of heat lost to the sur-

rounding atmosphere; and cleanliness of surroundings. The smaller amount of heat lost to the surrounding atmosphere makes the work around an electric furnace, especially in summer months, far more healthy and agreeable than with the combustion furnace.

The thermal efficiency of electric furnaces vary with the size and capacity in tons per hour, a furnace of 1 ton per hour of 2200 deg. showing an efficiency of 75 per cent. Most of the terminal troubles in electric furnaces for reheating have been practically entirely eliminated; for example, one set of electrodes now lasts for months at a time in continuous service. For furnace temperatures not exceeding 2500 deg. fahr., the electric furnace will answer any reasonable requirements, and, so far as actual fuel cost alone is concerned, at one cent per kw-hr., will compare favorably with oil furnaces burning oil at four cents per gallon.

In large tonnages of heavy billets, the combination of a combustion furnace using producer gas up to 1500 deg. fahr., and heating by electricity from this temperature to the desired rolling temperature offers the advantages of low fuel costs per ton of metal heated and a minimum amount of oxidation of the metal, beside protecting the electrodes. Such a furnace can be expected to show a thermal efficiency in the gas end of 50 per cent, and in the electric end of 75 per cent.

The author discusses, in some detail, the use of electric furnaces for soaking pit and for heat treating and annealing purposes. The type of furnace best adapted to heat treating is the automatic continuous furnace, where the metal under treatment when fired to the predetermined temperature is automatically discharged into the air or into some quenching medium. When the material at the discharge end of the furnace reaches the minimum temperature, a special pyrometer closes an electric circuit, which in turn closes, through a suitable relay, the solenoid-operated radial dial switch, and the various electrical circuits operate, in proper sequence, the doors, pusher and quenching apparatus.

In regard to the economy of small electric reheating furnaces from the fuel point of view alone, where the current consumption per ton is 480 kw. and the rate is one cent per kw-hr., they can be compared with oil where the consumption per ton is 100 gal. at four cents per gallon, or natural gas where the consumption per ton is 12,000 cu. ft. Electric furnaces of the continuous type, of 5 tons per hour capacity, will show a commercial economy over coal fired furnaces of the same capacity with coal at \$2 per ton (requiring 200 lb. of coal per ton of steel), while electric furnaces require an electric current consumption of 250 kw-hr. per ton with current at one-half a cent per kw-hr. The combined gas and electric furnace will show a commercial economy, compared with producer gas fired furnace using 200 lb. of \$2 per ton coal, while the combination gas and electric furnace uses 140 lb. of coal per ton of metal for heating it to 1400 deg. (30 pp., *gd*).

FRANKLIN INSTITUTE

Journal, vol. 179, no. 6, June 1915, Philadelphia, Pa.

High Temperature Investigation and a Study of Metallic Conduction, Edwin F. Northrup

Sound Steel for Rails and Structural Purposes, Sir Robert A. Hadfield

A Study of Some Curious Painting Phenomena, Henry A. Gardner (abstracted)

An Air Analyser for Determining the Fineness of Portland Cement (U. S. Bureau of Standards)

A Study of Some Curious Painting Phenomena, Henry A. Gardner

This paper includes an investigation of the destruction of paint, especially on buildings, by fungus growths.

The writer noticed that certain types of paint were affected by what is called mildew by painters; not everywhere, but more severely in sections which were shaded by trees or in partially sheltered nooks where dampness would be maintained for considerable periods of time.

Sections of painted surfaces showing marked formation of mildew were collected: In some instances, the mildewed surfaces were lightly scraped with a clean knife and the scrapings collected in a special envelope. A culture medium was then prepared which would exert an inhibitory action upon any ordinary bacteria which might be present upon the specimens, but which would permit the rapid propagation of the fungus spores.

As cypress is one of the most important woods used for construction purposes, especially in the South, where the investigation was carried on, a cypress decoction was prepared in the following manner: 50 grams of finely divided wood shavings were boiled in a half liter of distilled water. The decoction was filtered and ½ per cent of thread agar was added. After steaming to obtain solution, the mass was filtered, tubed and sterilized at 120 deg. cent. for 15 minutes.

The two principal types of fungi which were developed from the mildewed surfaces were shown to be species of *Aspergillus* and *Penicillium*. Tests have shown that black Aspergillus proved the more hardy, while others seemed dormant unless kept constantly moistened. In one test, the black mould, in a week's period, exerted a most destructive effect upon a board coated in white lead with oil, the oil apparently serving as a most favorable medium for this development, and thus playing a leading part in the reaction which results in the destruction of the paint and the exposure of the wood. The development of fungi in every instance was much more rapid upon paint coatings which were soft and subject to retention of moisture, while paints which presented a firm, hard, moisture-shedding surface resisted the fungi and prevented germination of the spores.

The author comes to the conclusion that micro-organisms may play an important role in the behavior of materials of paint, as shown by recent investigations into the causes of certain paint troubles referred to by painters as saponification or washing. This condition is generally indicated by the appearance of a white deposit at the base of porch columns and by the paint assuming a soap-like condition when rubbed. While instances of such action are rare, there was recently an apparent epidemic in one community. The author collected samples of the washed paint for analysis, as well as making analyses of the oil that was mixed with the paint paste by hand. The oil almost invariably was found to contain considerable moisture, as well as a large percentage of mucilaginous or albuminous matter, which is commonly called "foots." Portions of the "foots" from the various samples of oil collected were placed upon sterile agar, and in a few days marked growths of pink colored mould were obtained, identified later as a specie of *Fusarium*. Portions of this mould placed upon oil seemed to produce free acid, which explains the washing of paint in which the

infected oil was used. The enzymes and micro-organisms in the "foots" apparently exerted a fat-splitting action, the oil being broken up into glycerine and fatty acids, causing the formation of soap-like products which are acted upon by moisture, in addition to which the glycerine formed in the film serves to keep the paint soft and tacky, readily attracting moisture from the air. The moisture in its turn emulsifies with the soft paint, some of which washes off.

The washing of paint is not of uniform occurrence. It may be noticed upon the porch columns, but not in the body or trim of a house, and only upon certain sections of the main structure. The writer has observed that in most instances where washing has shown itself, it has generally been on a hollow column or a surface the back of which may hold moisture. It is likely that the moisture stored up in certain places is responsible for starting this reaction.

The so-called "rust" or brown spotting of paints may be traced, in some cases, to the action of soluble matter contained in the wood exuding at certain places in the paint film and drying up into small, hard globules. It may also be due to the nature of the oil if it contains moisture and "foots" of an infected nature. In such cases, the hydrolizing action of the enzymes apparently increases the tendency of the oil to break up into various fatty acids, including formic acid. This has a solvent effect upon the lead and zinc pigments, producing lead and zinc formates which are soluble in water.

From the above, it is apparent that the selection of a satisfactory oil is of very important consideration, especially upon repainting work. Immunization of oils is best done by the application of heat, which is not, however, directly feasible in some cases. On the other hand, mixtures of oil and pigments are often run through Buhrstone mills at temperatures up to 240 deg. fahr. (depending upon the rate of grinding and set of plates), which is more than sufficient for sterilization.

Tests by the author have shown that paint is in a most satisfactory condition after storage if the hot paste was allowed to cool before thinning and canning. When, however, paste paints are thinned by the painter, only clarified, well settled, moisture-free linseed oil should be used (15 pp., 15 fig. *epA*).

INSTITUTION OF MECHANICAL ENGINEERS

Advance paper B, read May 14, 1915, London.

The Distribution of Heat in the Cylinder of a Gas Engine, Professor A. H. Gibson and W. J. Walker

The paper presents data of tests having for their purpose the determination of how the distribution of heat throughout a gas engine varies with the speed of the engine, b.h.p., and the compression ratio, and richness of the air ÷ gas mixture.

Tests were carried out on an experimental gas engine recently installed in the engineering laboratories at University College, Dundee. This engine, with a cylinder diameter of 11 in. and a stroke of 19 in., afforded exceptional facilities for such investigations. The connecting rod could be lengthened so as to vary the compression ratio between the limits of 5.17 and 6.62. The cylinder jackets were divided into two parts, one of which surrounded the exhaust valve and the portion of the exhaust passage included within the cylinder casing, while the other covered the breech end and barrel of the cylinder. The jacket water was led in series through the two sections, the temperature being measured before and after passing through each of these. This made it possible to ascertain, with a higher degree of accuracy than usual, the heat lost to the jacket apart from that portion of it which correctly should be attributed to exhaust losses.

The normal speed of the engine was 200 r.p.m., but in the trials a range of speeds from 140 to 260 r.p.m. was examined. The b.h.p. was varied from zero up to full load capacity. Three different compression ratios and three different air-gas mixtures were used. In all, 130 trials were carried out, the details of which are described in the paper. In the main it was found that:

The *mechanical efficiency* of the engine increased with increase in loads; diminished as the ratio of air to gas increased; diminished as the speed increased and was sensibly independent of the compression ratio; the maximum efficiency attained in these trials at full load with the richest (7:1) mixture, and at the lowest speed (150 r.p.m.) was 88 per cent.

The *thermal efficiency* as measured on i.h.p. increased with the load; attained the maximum with an air-gas mixture of approximately 10 to 1; increased very slightly as the speed increased and increased as the compression ratio increased.

Thermal efficiency on b.h.p. increased with the load; attained a maximum with an air-gas ratio of 8 to 1, that is, with a richer mixture than gave maximum i.h.p. efficiency; diminished as the speed increased and increased with the compression ratio.

The *ratio of the actual thermal efficiency* measured on the i.h.p. *to the corresponding air cycle efficiency* increased with the load; had maximum value when the ratio of air to gas was approximately 10 to 1; increased slightly with the speed and was sensibly independent of the compression ratio. At full load and with the most efficient air-gas mixture, the relative efficiencies were for all compressions from 0.687 at 150 r.p.m. to 0.709 at 250 r.p.m.

The percentage *exhaust losses* diminished as the load increased; diminished very slightly as the ratio of air to gas increased; increased as the speed increased and diminished as the compression ratio increased.

Jacket losses. The percentage heat carried away by the water flowing through the cylinder jackets, not including the exhaust valve jacket, increased with the load; diminished as the speed increased and was sensibly independent of the compression ratio. Various facts indicated that the rate of transmission of heat through cooling surfaces was much greater at the higher speed in spite of a lower gas temperature. This was apparently due to the fact that the greater turbulency of the working fluid at the higher rates of speed increased its effective conductivity to an extent which more than counterbalances the effects of a smaller temperature difference and a shortened time of contact. Other things being equal, a 6 per cent increase in the temperature of the gases would probably increase the heat transmitted by conduction and radiation by some 15 per cent, so that it might be taken approximately that the effective conductivity was increased in the same ratio as the speed of the engine.

The *radiation loss* diminished as the load increased; increased as the ratio of air to gas increased; diminished as the speed increased and increased slighly as the compression ratio increased. (23 pp., 6 figs. *e.*)

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

No. 55, London.

TELEGRAPH TRAFFIC AND POWER PLANT FOR PNEUMATIC TUBES IN POST OFFICES, Alec B. Eason

The information in the paper was collected in order to form estimates of the cost of pneumatic installations and current for working various tubes. The problem of determining the probable traffic which the tube will carry under certain conditions, and especially the hourly maximum carrying traffic, is discussed. From this, the writer proceeds to the question of the quantity of air which will be needed to drive the carriers through the proposed tubes; and finally, the size, type and kind of pump which will be most efficient for the work and the probable over-all efficiency of the motor and pump. Only electrically driven sets are considered, these being, in the estimation of the author, the type used almost exclusively in modern installations wherever possible. Only the second and third sections of the paper (Air Required in Installations, and Pumps and Motors), are abstracted here.

In regard to air used per carrier in street tubes, the writer points out that when sending with pressure, the amount of air used for any practical container pressure may vary greatly, according to the types of cocks which are used and the amount of throttling in the circuits. The author describes a series of tests made to determine the amount of air and gives the following formula for the quantity of air used in tubes working intermittently:

$$Q = \frac{V}{13.08} \frac{p' - p''}{14.7}$$

where Q = pounds of air; V = the container volume in cubic feet; 13.08 = cu. ft. of air in 1 lb. at 60 deg. fahr.; and $p' - p''$ = drop in the container pressure in pounds per square inch, the temperature of the container being assumed to be constant during the time of the test.

In regard to vacuum working, it appears that with the same vacuum in the container, approximately the same amount of air, 7 lb., is used no matter what the throttling may be. The practical importance of this fact is that with intermittently worked tubes, used in an upward direction, one can introduce full bore services and get increased speed without increased consumption of air. The usual objection as to lax attendance applies to any kind of service, and although increased loss may occur when working with full bore cock, at increased speed, the amount of the increase is small and may easily be overbalanced by saving in the loss due to leakage in the three-way cocks, as the author shows by a calculation.

As regards working with different container pressures, it has been found that with a 5 lb. container pressure and full bore cock, the total time is 55 seconds as against a transit time of 53 seconds when using a container pressure of 8 lb. and the cock at half position; the consumption of air at the lower container pressure was five-sixths of that at 8 lb. pressure. It is best, therefore, to get rid of throttling and use lower container pressures.

Tests at Hull, made in 1911, have shown that the increased speed with high vacuum was obtained without any increase in air consumption, but it should be noted that the energy consumption is increased because the air is taken to a higher vacuum.

A series of tests were made on house tubes, i.e., those which lay wholly within one building. The author found that for house tube work, it would be necessary to allow a consumption of air of from $1\frac{1}{4}$ to twice the volume of the tube. If the speed is high, the consumption will rise to 2 or $2\frac{1}{2}$ times the volume of the tube. The loss due to differences in turning off the cocks promptly is relatively great, as the transit time of carriers is only 5 to 10 seconds.

The leakage of pneumatic tube systems may be divided into three kinds: *a* leakage from the container, pipe-work, and cocks; *b* leakage from the D boxes, double slide switches and fittings, and *c* leakage from the tubes. Leakage *a* occurs in the building, is easily noticeable and therefore should not exist to any great extent. Leakage *b* always exists, but varies in extent with the age and wear of the sliding portion of the fittings. Leakage *c* should not be allowed to any great extent, but it is difficult to locate the position of the leaks in street tubes and repairs to them are costly. Leaks are sometimes allowed to continue, therefore, as long as they do not affect the working of the tube too much. Leakage *a*, at Brighton, amounted to about 68 lb. of air per day, the total amount being 300 lb. The leakage at Hull, on a vacuum container, caused a rise of 2 lb. in $3\frac{1}{2}$ minutes, equivalent to about one-fifth of a pound per minute extra work. For leakage *c*, on London tubes the following amounts (including leakage *b* in some cases) were found: For individual tubes, .22, .30, .47, .37, .60, 5.4 lb. of air per minute. The total leakage for nine tubes working on pressure was 4.7 lb. and for twenty tubes worked on vacuum, 3.5 lb. The total *b* and *c* leakage in London is about 900 lb. per hour, or something like 5 per cent of the total load.

The author considers in detail the various types and dimensions of carriers, and comes to the conclusion that carriers should fulfill four requirements: *First,* large capacity; *second,* retentivity, which means that messages should not drop out of them; *third,* durability, and *fourth,* ease of manufacture. Metal carriers, to be satisfactory, must have buffers or felt skirts at both ends.

The author likewise discusses the various systems of working pneumatic tubes, such as the Dudley system installed when the tubes are short enough, and the high pressure system, with which a saving occurred when the ratio of the maximum load to the average was large. Tests with high pressure systems have shown that it was not worth while pumping air to high pressures. The usual limits were from 10 to 50 lb. per sq. in. and the investigation showed that the higher the pressure, the greater the total energy consumption, including the light load loss, for the whole day.

A careful investigation was made to determine the size of pumps required to deal with air under various conditions of pressure and vacuum as well as the size of motors needed to drive these pumps. The author derives a formula showing the rising pressure in the time t, when the speed of the pump is supposed to be constant. He also discusses the question of volumetric efficiency of the pump. The results of the tests at Hull, Brighton and Sheffield show discrepancies when compared with the usual theory. In general, the author arrives at the following conclusions:

The input to motors driving air compressors is 1.6 to two

times the work required to compress the amount of air dealt with isothermally between the working pressures (from tests, it has been found that working with pressure accurate figures for either volumetric efficiency or over-all efficiency cannot be obtained by noting the rise of pressure in closed containers). The maximum horse power input to motors driving vacuum pumps delivering it to the atmosphere, is 1/25 of the displacement in cubic feet per minute. (104 pp., 11 figs. eA.)

ROYAL SOCIETY

Proceedings, Series A, vol. 91, no. A 628, April 1, 1915, London

On Thermophones, P. de Lange.

A Bolometric Method of Determining the Efficiencies of Radiating Bodies, William H. Bone, H. L. Callendar, H. James Yates.

The Elastic Properties of Steel at Moderately High Temperatures, F. E. Rowett (abstracted).

THE ELASTIC PROPERTIES OF STEEL AT MODERATELY HIGH TEMPERATURES, F. R. Rowett

In a previous paper the author gave results of measurements of elastic hysteresis of steel tubes when subjected, at ordinary room temperature, to torsional stresses within what is ordinarily regarded as the elastic limit. In the present research, an attempt was made to establish the difference in the behavior under stresses at higher temperatures of both hard-drawn tubes and annealed tubes.

It was expected that the former, containing a good deal of amorphous material, would begin to behave like a viscous fluid,—that is, it would flow, more or less freely, under stress, whereas at the same temperature, the annealed tube being crystalline, though it might take a permanent set, could not flow or would flow to a much lesser degree, on account of the small amount of amorphous material in it.

It was found, actually, that at a temperature of 300 deg. cent., hard and annealed tubes began to show properties similar to those of pitch at ordinary temperature, or of glass at a temperature rather below the softening point. They were still highly elastic under varying stresses, but flowed perceptibly when the stress was applied for a great length of time, the energy dissipated in a cycle of stress depending upon the speed of the cycle. If the cycle was performed in five seconds, the area of the closed stress-strain loop was not much greater than at ordinary temperature and was less than that given by an annealed tube, but if the cycle took a quarter of an hour, the dissipation was increased four-fold.

In the annealed tube, however, at 300 deg. cent., the energy lost per cycle of stress was still almost independent of the time. At a higher temperature—for example, at 540 deg. cent.—the hard drawn tube flowed rapidly and continued to flow for a long period, though at a diminishing rate under a shear stress of less than one ton per square inch. At this temperature, steel, like pitch or glass, showed considerable after-working. Some flow and elastic after-working were also observed in the annealed tube at this temperature, but both of these tendencies were much less than in the hard.

The steel tubes had the following chemical composition: Carbon, 0.17 per cent; manganese, 0.24 per cent; sulphur, 0.02 per cent; phosphorus, a trace.

The elastic limit in torsion of the tubes as supplied by the makers was 13.8 tons per sq. in. shear stress in either direction, giving an elastic range of 27.6 tons per sq. in.

The data of tests are presented in the original article in the form of tables and curves. (13 pp. 4 figs.)

ROYAL SOCIETY OF ARTS

Journal, vol. 63, Nos. 3259 and 3260, May 7 and 14, 1915, London

(No. 3259) On the Measurement of the Efficiency of Domestic Fires, and on a Simple and Smokeless Grate, A. V. Harcourt (abstracted)

(No. 3260) Recent Progress in Pyrometry, Chas. R. Darling

ON THE MEASUREMENT OF THE EFFICIENCY OF DOMESTIC FIRES, AND ON A SIMPLE AND SMOKELESS GRATE, A. V. Harcourt

The writing of the present paper was prompted by a desire to determine whether a sprinkling of a solution of a powder in water, consisting mainly of common salt, on lump coal, burned on a domestic grate, increases the efficiency of the fire. Theoretically, this did not seem likely, but the writer wanted to establish definitely what actually would happen.

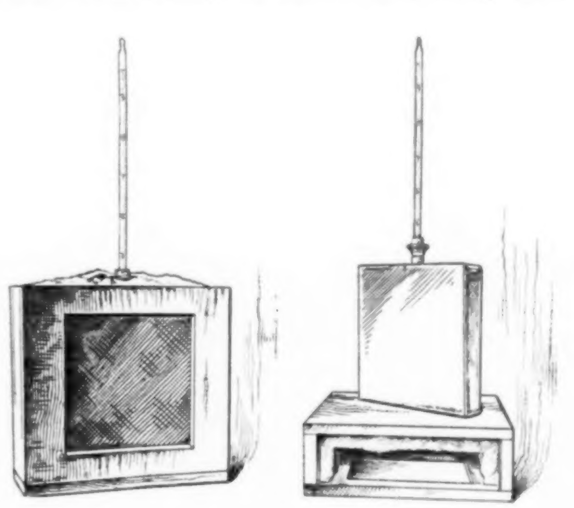

FIG. 7 "RADIO" THERMOMETER FOR MEASURING RADIANT HEAT

To do this, he found it necessary to measure the amount of heat radiated into a room, which led to the development of the instrument illustrated in Fig. 7, which the author calls a radio-thermometer, i. e., a measurer of radiant heat. It consists of a copper box 6 x 6 x 1 in., with a small funnel-shaped inlet, enclosed in a wooden box 7 x 7 x 2 in., open at the top and with an opening 5 in. square in the middle of one side. Except on this side, there is a space between the two boxes, of an inch at the back and ½ in. at the sides and below, loosely packed with cotton-wool. On the side which is in contact with the wood, the central 25 sq. in. are exposed and blackened. A thermometer, used also as a stirrer, is held by a cork in the opening at the top. It is furnished with a cup-shaped piece of sheet rubber tied on above the bulb, stretching across the box. The weight of the copper box is 11 oz.; that of the water which fills it, is 1 lb. 6 oz. The water-equivalent of the copper box is $11 \times 0.095 = 1.045$ oz.; hence the mass of water heated may be taken as 1 lb. 7.04 oz., or 1.44 lb.

The instrument having been freshly filled with cold water is placed facing the middle of the fire at a distance of 3 ft. Exactly on the minute by the watch, the thermometer is

read; about 9 min. later the water is briskly stirred up and down with the thermometer, which is then replaced with its bulb central, and at the end of 10 minutes, the thermometer is again read. These readings are repeated every 10 minutes until the temperature of the water is as much above the temperature of the air taken by a thermometer at the back of the instrument as it was below it at the start. The cotton-wool, which checks the flow of air around the box, prevents the temperature of the air in the room having too much influence, and both this and the exchange of radiation are approximately balanced by the temperature of the water, being to an equal extent and for nearly the same time, first lower and then higher than that of its surroundings.

To make the results, with the fire larger and smaller at different times, more nearly comparable, an estimate was made every ten minutes of the area of fire, from which the chief part of the heat was being radiated (this area is expressed in "spaces"). A large number of measurements have been made of heat radiated from coal, from coke, from coke which had been wetted and from coal and coke treated with a salt solution. The average results in units of the method are as follows: coke, 1.97; coal, 1.63; wet coke, 1.29; coke and coal sprinkled with water and powder, 2.03 (the presence or absence of the powder made no practical difference).

These results seemed to be probable. Coal, when it burns, passes through two distinct stages; first, it gives off gas, some of which is burned and some of which escapes unburned. When evolution of gas has ceased, the coal has been changed to coke and the second stage begins, when it burns with a steady glow. During the first stage, much less heat is radiated than during the second, as the heat from the burning gases goes chiefly up the chimney. Wet coke, if sufficiently wet, gives still less heat at any moment, for it burns more slowly and some of its heat goes to evaporate the water.

From this, the author proceeds to the description of a special grate for use in domestic fires. He establishes a number of principles which should be observed in the construction of a domestic fire grate and points out that in addition to purely technical requirements, the grate must not be less attractive in appearance than other grates. He shows, however, several quite attractive illustrations of his design. (9 pp., 7 figs. *gpd.*)

WESTERN CANADA RAILWAY CLUB

Proceedings, vol. 7, no. 8, March 1915, Winnipeg.

The Handling of Fuel Oil in Extreme Climatic Conditions, Lorimer.

The paper discusses the use of oil fuel generally, and in very cold regions in particular, and described the design of special tank cars and storage tanks.

The ordinary tank car is usually of too small a capacity, say 8,000 U. S. gal., which means transportation of a comparatively heavy dead load for a small quantity of fuel. Also its design is not convenient; for example, it has the valve located about 2 ft. off the center line, hence, in making up the train, the cars have to all be headed the same way, which, in railway practice, is almost impossible. Then it has a small opening in the dome which is generally closed by a round cover provided with a thread, a very objectionable arrangement, especially in very cold weather. Such tank cars are not provided with steam heating pipes and, with an outlet of only 4 in. exposed to the cold weather, it takes a long time to empty the car and, further, it is almost impossible to empty it completely because of the bottom of the car being level. As much as several hundred gallons may remain in the car, and thus not only reduce its effective capacity but remain to be carried back and forth on the line.

To obviate all these objections, a new tank car has been designed with a capacity of 10,000 Imperial gal. It has a dome provided with an opening of 18 in. x 36 in., the cover being hinged and hermetically sealed by means of eye bolts and hand nuts (this makes opening easy in any kind of weather). To make the spotting of the car easy, it has been provided with an outlet valve exactly in the center, and the steam inlets for heating the car are also placed exactly on center, one on each side of the car, so that the car can be headed either way. For purposes of heating, the car is provided with the piping so arranged that the steam starting from the center will travel at once toward the two ends and then come back to the center around the outlet valve which is in its turn provided with a steam jacket, the water of condensation being discharged through a Sarco valve of ample capacity.

For rapidly and completely emptying the car tank, there is provided a trough running longitudinally between the bolsters. This trough is 8 in. wide and riveted to the bottom of the tank is a semi-cylindrical bottom with a depth of 6 in. at the outside extremity and 1 ft. in the center. The outlet valve is riveted to this trough. Six 6 in. and one 6 in. x 18 in. hole in the center let the oil run through the whole length of the car into the trough. The return steam pipe is placed in the bottom of this trough and is connected to the steam jacket of the outlet valve. This permits the oil to be heated thoroughly and run quickly, while the 6 in. fall of the trough towards the outlet valve allows the car to be completely emptied.

The body of the car is composed of a center sill and two body bolsters, resting on the trucks. The center sill, 37 ft. 3 in. in length over striking plates, or 39 ft. c. to c. of couplings, is made of two 12 in. 40 lb. ship-building channels (Carnegie Section) spaced 12⅞ in. back to back. The two ends up to the bolsters are covered top and bottom by ½-in. cover plates, and between the bolsters, the bottom flanges of the channels are strongly latticed together, and the top flanges are reinforced by two 8 x 3½ x ½ in. angles.

The saving of weight due to this kind of design is about 3,500 lb. per car, the approximate weight of an ordinary tank car of the same capacity being about 44,000 lb. (24 pp., *gpd.*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

MEETINGS

WORCESTER, APRIL 8

At a meeting of the Worcester Section of the Society on April 8, the following committee was appointed: Paul B. Morgan, chairman; Carl F. Dietz, H. P. Fairfield, F. W. Parks and E. H. Reed, secretary.

ST. LOUIS, MAY 19

A meeting of the St. Louis Section was held at Washington University on May 19 and was presided over by Mr. J. W. Woermann, President of the St. Louis Engineers' Club. There was no single paper as such, but a general discussion took place covering the requirements and length of an engineering course of study. Professors A. S. Langsdorf, J. L. Van Ornum, E. L. Ohle, G. O. James, of Washington University; and Professor E. L. McCausland, of the University of Missouri, led the discussion. After the discussion, inspection of the laboratory at Washington University was made.

CINCINNATI, MAY 20

At a joint meeting of the Cincinnati Section of the Am.Soc.M.E. and the Engineers' Club of Cincinnati on May 20, Dr. A. O. Zwick gave an illustrated lecture on Egypt, Light of the World, which showed how our modern civilization is based upon the works of the Egyptians. They originated many of the present-day professions, and their knowledge of many branches of science was more highly developed than was found in our civilization 150 years ago. Dr. Zwick also showed how to compute the ages of the great Egyptian monuments and other structures that were erected some 13,000 years ago. Through the key to the Egyptian language (the Rosetta stone), found by an engineer, many valuable works have been translated which reveal that a remarkably high degree of development in culture and science existed in that remote period.

ST. LOUIS, JUNE 9

A joint meeting at the St. Louis Engineers' Club rooms, presided over by Mr. J. T. Garrett, Vice-Chairman of the local section of the American Society of Engineering Contractors, was held on June 9. The paper of the evening was by J. B. Emerson, of the Robert W. Hunt & Company, on "Needed Improvements in Specifications." The main points brought out were: *First*, too many specifications, while calling for specific tests, do not state with what frequency such tests should be applied; in other words, the number of tests per unit, or number of units per test, being entirely omitted. *Second*, the general clause of many specifications conflict with details given later, leading to much ambiguity. *Third*, the working limits of dimensions given should be more clearly defined. A specification without such limits, in the hands of an inexperienced inspector, causes the contractor a great loss, calling for minute measurements which are neither required nor desirable in that class of work. This paper was discussed by H. M. Cryder, Mr. Cramer, and others.

This was followed by an outline of tests being made by the United States Bureau of Standards, on full sized columns, by Dr. R. G. Olhausen. The total attendance was 46.

MINNESOTA, JUNE 11 AND 12

A joint meeting of the Minnesota Section with the Minnesota Section of the A.I.E.E. was held on June 11 and 12 in Duluth. Mr. Ryerson of the Great Northern Power Company gave a paper, illustrated by lantern slides, on the Great Northern's development and business. Mr. Hearding of the Oliver Iron Mining Company gave a moving picture talk on the Iron Ore Industry of Minnesota. The pictures showed all the process in the mining, from the prospecting to the loading of the ore on the boats for shipment.

The second day of the meeting was taken up with excursions, which included various docks and the new plant of the Minnesota Steel Company.

LOS ANGELES, JUNE 15

A joint meeting of the technical societies in Los Angeles was held on June 15. William Mulholland, chief engineer of the Los Angeles water board; James A. B. Sherer, president of Throop College of Technology, and Samuel Storrow, addressed the meeting on The Service of the Technical Man to the Community.

ST. LOUIS, JUNE 16

A joint meeting under the auspices of the A.S.M.E. was held on June 16, at which Edward Flad, Chairman of the local branch of the A.S.M.E., presided. The paper of the evening was by E. R. Fish, secretary of the Heine Boiler Works. His paper was entitled: Boiler Explosions, and What the A.S.M.E. is Doing to Prevent Them. He traced the development of the idea of standard specifications; how the requirements for safety in boilers were first put into concrete form by Thurston; showed how closely the A.S.M.E. Code fulfilled Thurston's outline requirements. He then told of the lack of uniformity of boiler codes among the various states, and the efforts being made by American Boiler Manufacturers Associations to obtain the adoption of the new code, by all of the state legislatures.

The lecture was concluded with illustrations showing boiler explosions and bad conditions due to failure to follow best engineering practice, both in design and operation of boilers.

There was an interesting discussion following the presentation of the paper by Edward Flad, Prof. E. L. Ohle, L. A. Day, Wm. Hoffman, and others.

At the same meeting the report of the joint committee was made, on the proposed water power development through diverting water from the Missouri to the Meramec Rivers. Previously the Missouri State Legislature had reported on this project favorably, estimating a probable development of 200,000 hp. The Engineers' Club report was distinctly unfavorable, showing that the possible horse-power was only 37,000, and the cost of development much more than that estimated by the state legislature.

NECROLOGY

EBENEZER HILL

Ebenezer Hill was born in South Norwalk, Conn., on October 5, 1849. He graduated from Wesleyan University with a degree of B.A. in 1870, and with a degree of M.A. in 1891. From 1870 to 1880 he was engaged, in connection

with others, in the design, construction and installation of steam pumping machinery and steam engines of various types. In 1880, he became the responsible executive head of the Norwalk Iron Works Company, and shaped the business to the manufacture of air compressors and allied machines. He held this position up to the time of his death, which occurred on February 26, 1915.

JOHN PHILIP ZIPF

John Philip Zipf, Jr., was born at West Point, Cal., on March 19, 1888. He attended the California School of Mechanical Arts and the University of California, from which he graduated in May, 1912. After graduation, he worked with Mr. R. F. Chevalier, a consulting engineer, in testing boilers for numerous gas and power plants in and about San Francisco. In December, 1912, he accepted a position with the Ramie Fibre Company of San Francisco as draftsman. After the failure of this company, he accepted a position with the Sutter Basin Company of Sacramento as draftsman of plans for electric pumping machinery for their reclamation project. Having completed their work in May, 1914, he entered the office of the California State Engineer at Sacramento, Cal. Mr. Zipf died at his home in San Francisco, Cal., on May 24, 1915.

BENJAMIN FRANKLIN ISHERWOOD

Benjamin Franklin Isherwood was born in New York on October 6, 1822. He was educated at Albany Academy and afterward served under David Matthews, master mechanic of the Utica and Schenectady Railroad. He was promoted to the civil engineer's office and, on the completion of the road, he went to work on the Croton aqueduct. After this was completed, he worked on the construction of the Erie Railroad under Charles B. Stuart, division engineer, who later became engineer in chief in the navy, and it was through his influence that Mr. Isherwood entered the navy in 1844. Later he was assigned by the U. S. Treasury Department to work on the construction of light houses, and was sent to France to superintend the construction of light house lenses there from his own designs. At the outbreak of the war with Mexico, he served on board the Princeton, the first American screw steam vessel built by Ericsson for the government as an experiment. He was promoted to be chief engineer of the Spitfire, and he took part in every action in which the American fleet was engaged during the war.

His experiments in the expansion of steam on board the U. S. S. Michigan in 1859 almost revolutionized the methods of using steam. He designed the engine of the U. S. cruiser Wampanoag, which was built in 1868 and which was the fastest steamship in the world at that time. She had a speed of seventeen and three fourths knots.

He was chief engineer in the navy from 1861 to 1869, covering the entire period of the Civil War, when more than six hundred steam vessels and three thousand engineers were in the service.

During the years 1870 and 1871, he was stationed at the Mare Island Navy Yard, California. His experiments there with screw propellers are regarded as among the greatest additions to engineering. He was retired as chief engineer with the rank of rear admiral on June 6, 1884. He was the author of many engineering works, some of which have been used widely as text books in technical schools.

Mr. Isherwood died at his home in New York City on June 19, 1915.

PERSONALS

Thomas R. Cook, until recently assistant engineer of motive power, Pennsylvania Lines West, Pittsburgh, Pa., has accepted the position of chief engineer of the Willard Storage Battery Company, Cleveland, Ohio.

Everett W. Swartwout, formerly of the Chicago office of the Nordberg Manufacturing Company of Milwaukee, is now associated with M. N. MacLaren in the New York office of the company.

John E. Lord has accepted a position with the Nordberg Manufacturing Company as manager of their Chicago office. He was until recently with the Buckeye Engine Company.

Myron J. Bigelow, who was connected with the Molyneux Mailing Machines Company of Buffalo, N. Y., has severed his connection with that company and is now consulting engineer, located temporarily in Akron, Ohio.

Gustave R. Tuska, consulting engineer, New York, has been appointed lecturer in municipal waste disposal at Columbia University, New York, and will deliver a course of lectures on this subject at the University during the coming year. Mr. Tuska has for some years been acting as consulting engineer to various garbage, refuse and waste disposal plants both in this country and abroad.

Ronald C. Hands has become affiliated with the Winchester Repeating Arms Company, New Haven, Conn., as assistant to the supervisor of the mechanical division. He was, until recently, connected with the planning and efficiency work of The Bridgeport Brass Company, Bridgeport, Conn.

David J. Lewis, Jr., has become associated with W. J. Wayte, a chemical engineer, with offices in New York, operating as consulting engineers under the title of W. J. Wayte, Incorporated. Their specialty is the utilization of wastes in power and manufacturing plants, especially in sugar and chemical works.

T. Omdal, formerly mechanical engineer with Lieberman and Sanford Company, New York, is now a member of the firm of The Equity Iron Works, Brooklyn, N. Y.

William E. Choate, acting general manager of the Carr Fastener Company, Cambridge, Mass., will leave that position August 1 to take a similar one with The Advance Machine Company of Boston, Mass.

John E. MacArthur, formerly connected with the Pierce-Arrow Motor Car Company and more recently superintendent of the Keystone Manufacturing Company, resigned on May 1 to become general superintendent of the Robinson Fire Apparatus Manufacturing Company of St. Louis, Mo.

Jacob M. Howarth has become associated with Marshall Field and Company of Chicago, Ill., as assistant chief engineer. He was until recently mechanical draftsman and test engineer in the U. S. Yards of Swift and Company, Chicago, Ill.

Harold K. Beach has been transferred from the Atlanta, Ga., office to the New York office of Lockwood, Greene and Company.

William E. Bullock has resigned his position as assistant to the Secretary of The Franklin Institute and has been appointed on the editorial staff of the Am.Soc.M.E.

George B. Massey has resigned as foreign sales manager of the Bucyrus Company and has formed the Geo. B. Massey Company, consulting engineers, on excavating machinery and methods, with offices in the Peoples Gas Building, Chicago.

Edwin G. Hatch has opened an office for consulting work in the Equitable Building, New York, and will have associated with him Herschel C. Parker, for twenty-one years professor of Physics in Columbia University. Mr. Hatch was formerly associated with Walter G. Clark of New York, specializing in electrical work, having entire charge of the work in New York since 1913, during Mr. Clark's absence in the West. Mr. Hatch was also treasurer and manager of the Clark Electric Company, and was largely instrumental in developing the company's high tension line apparatus.

STUDENT BRANCHES

CARNEGIE INSTITUTE OF TECHNOLOGY

The last meeting of the year held by the Carnegie Institute of Technology was addressed by George H. Redding, assistant secretary of the Institute, on The Success of Mechanical Engineering Graduates of the Carnegie Institute of Technology.

Mr. Redding first told of the method used for keeping statistics of the graduates. Every year a blank is sent to each graduate to be filled out and returned to the Institute. The information asked for included the kind of work being done, the salary being received, and whether the man is satisfied with his work. He is also asked in what range his salary lies. In reply to the last question, the following ranges have been submitted: 900-1200, 1200-1500, 1500-1800, 1800-2000, 2000-2500, and above 2500. This method has proved quite satisfactory, and most of the graduates have responded with the required information. Mr. Redding said that, however unfair it might be to measure a

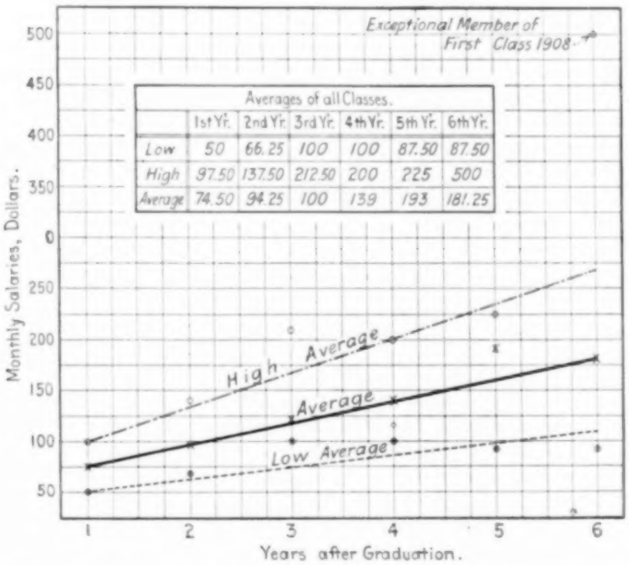

FIG. 1 CURVES OF SALARIES OF GRADUATES IN MECHANICAL ENGINEERING OF THE CARNEGIE INSTITUTE OF TECHNOLOGY, SCHOOL OF APPLIED SCIENCE

man's success by the salary which he receives, it is their only means of tabulating and representing in graphical form the progress of a large number of men over a period of years, and that the accompanying chart would give young engineers a fair idea of what they might expect when they got out into the world of working men. The data which has been used has included information from approximately ninety per cent of the mechanical engineering graduates. Some men just out of college become, in a short time, dissatisfied with the routine and grind which must always be undergone if success is to come. It is a significant fact, however, that the majority of these mechanical engineers who deviated from engineering work eventually went back to the field for which they were trained. One man, for instance, a graduate of early years, went into another field of work in which he was able to make a very large salary. He is now, however, doing mechanical engineering work whereby he can gain additional experience, and, although his salary is small, he says that he is satisfied.

COLORADO AGRICULTURAL COLLEGE

At a meeting of the Colorado Agricultural College Student Branch on May 29, Professor Crain addressed the society on the uniflow engine. He described first the heat loss that takes place in the counterflow engine, due to the condensation, and how the loss is minimized by the uniflow principle. He then described the Stumpf Uniflow Engine which has been developed in Germany. The Stumpf engines are run condensing, and, in order to meet the American requirement of running non-condensing, an auxiliary valve has been added. By means of diagrams, he illustrated the difference between the valves of the counterflow and those of the uniflow engines.

KANSAS STATE AGRICULTURAL COLLEGE

At a meeting of the Kansas State Agricultural College on June 9, the following officers were elected for the coming year: L. A. Wilsey, president J. I. Michaels, vice-president; F. R. Rawson, secretary, and Charles Zimmerman, treasurer.

W. L. Rhoades, a senior in the mechanical engineering course, gave a paper on Variable Compression on the Economy of a Corliss Engine, which were the results of a thesis which was carried on by him and A. H. Ganshird on the economy of a simple, non-condensing Corliss engine. They gave as the results of their tests that as the compression increased up to about eighty per cent of the initial steam pressure, the economy of the engine increased. From the results of Clayton's analysis, the conclusion was made that there was leakage past the piston of the engine used in the test.

Shelby Fell, a senior in the course of electrical engineering, gave a paper on Tests of a Mercury Arc Rectifier, which were the results of his thesis which was performed to determine the efficiency, shape of the wave and losses of a mercury arc rectifier.

PENNSYLVANIA STATE COLLEGE

A meeting of the Pennsylvania State College Student Branch was held on May 19. W. D. Garman, president of the Branch, read a paper on Student Branches of the A.S.M.E. issued by the Society.

The following officers were elected for the coming year: H. L. Mummert, president; G. H. Dunn, vice-president; E. J. Kenney, secretary; P. N. Ziegler, treasurer, and Prof. J. P. Calderwood, of the Advisory Committee, to countersign checks.

PURDUE UNIVERSITY

A meeting of the Purdue University Student Branch was held on May 18, at which the following officers for the coming year were elected: W. F. Miller, chairman; R. B. Stein, vice-chairman; H. R. Snyder, recording secretary; L. C. McAnley, corresponding secretary, and O. F. Hambrock, treasurer.

C. T. Sprado, chief designing engineer with the Allis-Chalmers Manufacturing Company of Milwaukee, spoke on Gas Engine Practice. His discussion was mainly on the internal combustion oil engine, the study of which he has spent some twelve years. The oil engine that was described was the one made by the Allis-Chalmers Company. Illustrative slides were used, showing each part of the engine in detail. The engine is of very late development, very similar to the

gas or gasoline engine in construction. A horse-power, however, can be developed at a much lower figure than by either of the other engines. Each part of the engine was taken up and explained in detail, the first part discussed, being the different types of plungers used and the one that has proved most satisfactory. In discussing the different types of valves, Mr. Sprado made the statement that the valve being used at present on the piston is almost perfect in design. It has been tested in their shops, and has been in use on engines that run continuously twenty-four hours a day for six months without stop. The Allis-Chalmers engine has many improvements in the working of the piston which makes it distinctive above all other types.

Mr. Sprado also made a comparison of the vertical and horizontal types of engines. He disproved the idea that most people seem to have that the horizontal engine takes more floor space than the vertical. He showed that the lubrication of a horizontal engine was more thorough and the system much simpler. A vertical engine is not guaranteed to be started in less than five minutes and it is a considerable job. The horizontal engine made by the Allis-Chalmers people may be started in less than one minute. Following this, a few slides were thrown on the screen, showing efficiency curves of the different types of engines.

SYRACUSE UNIVERSITY

A meeting of the Syracuse University Student Branch was held on May 21, at which the following officers for the coming year were elected: D. R. Hay, president; S. S. Amdursky, vice-president; H. B. Tracy, secretary, and E. H. Brooks, treasurer.

Dr. John E. Sweet gave a lecture on Harmony of Theory and Practice, and gave many examples where theory and practice do not harmonize. Principles worked out by scientists very many times cannot be adopted in engineering projects. The impression left with the audience was that an engineer's experience is worth much more to him than his technical training, but that he must have both to be successful, and that he must not place too much faith in pure science, but realize that he must separate by his accumulated knowledge the practical from the impractical.

THROOP COLLEGE OF TECHNOLOGY

At the regular meeting of the Throop College of Technology Student Branch, held on May 19, Harold Doolittle, assistant construction engineer of the Southern California Edison Company of Los Angeles, told about the construction and the operation of their plant at Long Beach. Most of the students had been to see this plant on an inspection trip a few weeks before this, so that the illustrations and descriptions given by Mr. Doolittle helped to make many of the things clear. This plant, supplying power to a large number of towns and cities of Los Angeles County, has three Curtis turbines, 12,000, 15,000 and 20,000 kva., with sufficient building space for the addition of a fourth unit.

On May 21, a meeting was held at which the following officers were chosen: V. E. Farmer, chairman; C. H. Ridenour, vice-chairman; J. A. Beattie, secretary, and Arthur Stert, treasurer.

UNIVERSITY OF CINCINNATI

The largest meeting of the school year of the University of Cincinnati Student Branch was held on May 21, at which the following officers were chosen: A. J. Langhammer, president; R. S. Rickwood, vice-president, and W. T. Cowell, secretary and treasurer. The speaker of the evening was A. M. Sosa, chief draftsman of the American Tool Works Company. His subject was Pitfalls Along the Path of the Young Engineer. The speaker pointed out that engineers after graduation separate very quickly, and that each individual had the same set of tools, so to speak, at his command. Now, if never before, the graduate will ask himself the questions: "What is my value? What have I learned and what have I yet to learn?" If an employer were to answer these questions, he would say: "You are praiseworthy, but you lack experience."

During his course the student has learned many things. He has studied physics, mathematics, mechanism, etc., and he has been taught to handle instruments skillfully. However, when a student assumes a position, his work is along one branch of the subject he has studied. He may find that this particular branch has been given but little time in his course. His efforts from now on are concentrated upon this one branch and its details; and as he progresses in his work his knowledge of the science of engineering increases and he gains his experience. The young engineer now realizes that by experience is meant the history of that particular branch of engineering which he is following.

Mr. Sosa emphasized that engineering work is primarily analytic, and if one error is made in the analysis the mistake will show. All engineering knowledge is the result of three things—observation, comparison and combination, and to get results, it is not necessary to know the precise nature of certain phenomena; for example, heat, electricity, friction, etc. We know that, under certain conditions, each will exhibit certain characteristics, and to a man on the job this is quite enough. When new fields are being explored, the methods are analogous; that is, certain facts are discovered, laws are formulated, and results are derived from these.

Professors A. L. Jenkins and A. C. Joerger gave short addresses.

UNIVERSITY OF MINNESOTA

A regular meeting of the University of Minnesota Student Branch was held on May 6, to which the whole sophomore mechanical engineering class was invited. Professors Martenis, Shoop and Rowley, and Mr. Colvin, of the Post-seniors, spoke on the general theme of membership.

The meeting held on May 13 was open to the whole engineering college, at which H. S. Whiton, of the Minneapolis General Electric Company, spoke on System Operation. He very interestingly described the problems and woes of the operator of a large light and power distribution system like that in the city of Minneapolis. The slides which he used to illustrate his lecture showed the power plants and branch station of the Minneapolis General Electric Company.

The last regular meeting of the Branch was held on May 20. The meeting was called to order to give Mr. Shoop, of the Experimental Engineering Department, a chance to speak to the senior and post-senior men about connecting themselves with the national Society as Junior members.

UNIVERSITY OF NEBRASKA

At a meeting of the University of Nebraska Student Branch on May 4, the following officers were elected: L. L. Westling, chairman; R. B. Saxon, secretary, and W. C. Chapin, treasurer.

WORCESTER POLYTECHNIC INSTITUTE

At a meeting of the Worcester Polytechnic Institute held on May 21, the following officers were elected: Harold Nutt, chairman; Thomas W. Farnsworth, vice-chairman; John A. C. Warner, secretary, and Everett H. Francis, treasurer.

Following the executive business, abstracts from several senior theses were read. Among them were Investigation and Test of a White Gasoline Motor, by Harrison W. Hosmer and George W. Smith; Heat Treatment of High Speed Steels to Meet the Cutting Requirements of Different Metals, by Ralph C. Nourse and Austin E. Poirier; and Test of the Westinghouse Electric Lighting, Starting and Ignition System, by Clifton P. Howard and Raymond P. Lansing.

This meeting brought to a close the first year of the Worcester Polytechnic Institute Student Branch. The meetings of the year have been well attended, and, by resort to publicity, the open meetings have been well attended by an interested public, and it is believed that the work of the Branch has been of value not only to the Institute, but to the community as well.

EMPLOYMENT BULLETIN

The Secretary considers it a special obligation and pleasant duty to be the medium of assisting members to secure positions, and is pleased to receive requests both for positions and for men. Copy for the Bulletin must be in hand before the 18th of the month.

POSITIONS AVAILABLE

The Society acts only as a "clearing house" in these matters and is not responsible where firms do not answer. In sending applications stamps should be enclosed for forwarding.

0147 Designer on dies for forgings. Location, New York.

0148 Draftsmen wanted for work on small machine parts. Location, New York.

0149 Wanted: A man to analyze and make recommendations for cutting shop costs; must be familiar with the latest shop practice, be able to figure speeds and feeds and make time studies. Work covers foundry, pattern and machine shops and building power house equipment. Give full information in first letter. Name of company confidential. Location, New York State.

0153 Wanted for Pittsburgh territory young mechanical engineer, as engineering salesman for high grade power plant steam apparatus; condensers, jet apparatus, re-cooling plants, water heaters, etc. Some experience in selling preferred. Apply by letter.

0155 Sales manager for Chicago office of manufacturers of power accessories. Desire a man who is well acquainted with the mechanical engineers in Chicago and surrounding territory. Must be well versed in power plant work, industrious and not afraid to work. Apply by letter.

0156 Engineer for inspection of machine parts. Knowledge must cover quality of machine work and parts. Location, New York.

0158 Checkers on detail drawings of Diesel engines. Men of experience in checking drawings, but not necessarily those who have worked at this particular line. Location, New York.

0160 Young graduate in engineering who has had at least two years experience in heating and ventilation. Location, Michigan.

0163 Chemist for works of manufacturing chemist. Location, New Jersey.

0164 Foreman of shop for manufacturing chemist. Location, New Jersey.

0165 Assistant engineer with experience in supervision of power plant and factory design. Chemical plant experience specially desired, though not necessary. Location, New York.

0166 Position of general manager of sales is open to a man of ability and equipment with a large firm manufacturing heavy machinery. Experience in sale of both steam and gas engines essential. Name strictly confidential.

0167 Foreman for plant repair department of Connecticut concern; department is largely general mill repair work; must be able to handle machinists, millwrights, carpenters, blacksmiths, laborers, masons, etc., and should possess the ability to supervise and keep varied work going at the same time.

0168 Mechanical engineer, capable of taking charge of development department of company manufacturing stokers. Man having experience with forced draft stokers preferred. State age and experience, giving full details and salary expected. Apply through Society.

0170 A consulting engineer of New York, with practice in a special field which can be greatly extended, desires to take into partnership an engineer who can invest some money and with qualifications for conducting investigations in the fields of physics and applied mechanics. Apply by letter.

MEN AVAILABLE

The published notices of "men available" are made up from members of the Society. Notices are not repeated in consecutive issues of the Bulletin. Names and records are kept on the office list three months, and at the end of such period if desired must be renewed.

G-170 Member, sales engineer, located in New York, good correspondent and estimator, broad acquaintance in manufacturing, engineering, and expert in field work, and experience in handling successfully well-known accounts in New England and Eastern States, desires to negotiate with manufacturer wishing a reliable representative in New York who will accept the responsibility for the management and results.

G-171 Member, with an unusually thorough experience in manufacture, and with first class record as executive, at present in successful consulting practice in scientific management, and especially successful in developing capable men, desires manufacturing executive position.

G-172 Member, graduate M.E., ten years experience in the operation of power plants, now specializing in selling coal to power plants, understands selling coal on specifications, desires position as fuel engineer with a dealer or producer of coal.

G-173 Graduate M.E., age 25, two years experience in office work and drafting department of a heating and ventilating concern, desires position in the same or along similar line.

G-174 Junior, aged 26, seven years experience embracing machine shop, drafting room, installation, production and estimating, desires position as assistant to executive or consulting engineer. At present employed but is seeking advancement.

G-175 Member, specializing in the installation of scientific management, can take on a limited amount of additional work.

G-176 Member, age 40, with 24 years of broad, practical and theoretical experience in erecting, operating and consulting capacities, also as master mechanic and mechanical superintendent in connection with the manufacture of ma-

chinery and prime movers, and in the maintenance, reconstruction and operation of paper and jute mills, desires position in either power plant or mill work.

G-177 Associate member with 20 years experience covering general office work, advertising, domestic and foreign sales, with knowledge of shop cost and wage systems and a wide general technical knowledge, has had more than four years business experience in fourteen foreign countries; broad acquaintanceship both at home and abroad and could develop foreign sales or promote manufacturing or sales branches abroad, desires to get in touch with growing concern that desires to increase business. Would accept a nominal salary with an agreement for bonus based upon results or a moderate fixed compensation.

G-178 Member, works manager and mechanical engineer, with nine years experience as engineer on water works, electric power station and steam engine work, twelve years experience as manager and designing engineer, manufacturing plant, building gas engines, automobiles, pumps, tractors and excavating machinery and with six years experience with efficiency methods, has managed 1900 men, laid out, built, equipped and organized plants, would like to build and organize new plant, or improve a growing plant.

G-179 Member, Cornell graduate, age 31, married, six years experience in refrigerating engineering and general power plant work, two years experience in teaching, desires position for the coming academic year in mechanical department of a technical school.

G-180 Member, age 46, technical graduate, married, experienced in engineering work with prominent engine builder and as resident engineer and chairman of safety committee of steel works, desires position. Salary, $3000.

G-181 Factory superintendent or foreman, 15 years executive experience, capable of producing results; practical machinist, toolmaker, and thoroughly conversant with modern manufacturing methods, organizing and increasing production.

G-182 Technical graduate, wide experience as railway mechanical engineer, as machinist, motive power draftsman and mechanical engineer desires position along these lines, or one as mechanical inspector, assistant superintendent motive power, or assistant to general manager. Location, immaterial.

G-183 Associate-member, Stevens graduate, age 27, six years gas engine experience in designing, experimental, testing, machine shop work and sales, desires position as assistant to superintendent or other responsibility.

G-184 Engineer with five years experience in steam turbines, power plant and reinforced concrete work desires permanent position. At present employed.

G-185 Young technical graduate, single, desires work in any branch of the engineering profession.

G-186 Member with broad experience of over 20 years as general manager of large plant including foundry machine and metal working shops, also in charge of sales and financial development and practical experience in all departments, desires position along the same lines.

G-187 Associate-member, age 34, graduate M.E., ten years consecutive and successful experience from machine shop to designing engineer; four years experience in design and construction of ordnance equipment of navy department; five years in design of special machinery, hydraulic machinery and in layout of power plants. Has held positions as draftsman and designer and U. S. Junior engineer and as assistant engineer on construction. At present employed but desires to make change.

G-188 Member, technical graduate, 12 years experience in design, operation and maintenance of heat, light and power plants, especially in improvement and supervision of power plant to obtain greater efficiency. At present employed but wishes to connect with firm of engineers or private corporation.

G-189 Member, age 37, technical graduate, two years consulting and betterment work in factories, ten years experience in designing, engineering production and accounting lines in manufacturing steam, gasoline and automobile engines and light and heavy machinery, desires position.

G-190 Junior, 1914 graduate Massachusetts Institute of Technology, desires position with a mill architect of manufacturing concern. Any position offering good experience and a chance for advancement will be considered.

G-191 Young engineer with technical training and two years experience in the design and manufacture of high duty pumping engines, and one year in the construction and maintenance department of large public service corporation in New York, desires position with a future with firm located in the Middle West.

G-192 Junior member, graduate in mechanical engineering, assistant to steam engineer in large manufacturing works, with experience in power plant supervision and boiler room efficiency, and with knowledge of power costs and distribution in manufacturing, desires position as steam engineer.

G-193 Junior member, Columbia graduate, thoroughly experienced in railway, construction and electrical lines, desires position with consulting engineer or contractor, or similar line. At present employed.

G-194 Junior member, graduate M.E., three years varied experience, desires position as laboratory instructor.

G-195 Junior member, Stevens graduate, energetic, resourceful, capable of handling men, eight years experience in engineering with firm manufacturing power plant equipment, also shop and drafting room experience, desires position which does not necessitate traveling. Has specialized in steam engineering.

G-196 Member, in consulting practice, with broad experience in perfecting general organization of manufacturing companies and in efficiency operation of plants, including familiarity with various processes of manufacture, particularly metal working, is open to temporary or permanent connection. Under suitable conditions will take stock or interest in profits as part compensation for services.

G-197 Junior member, age 27, Stevens graduate, possessing unusual mathematical ability, and with four years experience in experimental, plant and executive work, desires position. At present employed, but will be open for position in July.

G-198 Member A.S.M.E. and A.S.T.M., technical graduate, age 38, four years learning machinist trade, 13 years experience in executive positions with two companies manufacturing brass and iron steam specialties such as valves, lubricators, etc. Familiar with foundry, finishing and assembling operations.

G-199 Associate-member, graduate Swiss Government's mechanical school, command of French and German, eleven years practical experience as machinist, tool-die maker, tool department, foreman, draftsman, machine and tool designer and inspector, familiar with modern manufacturing methods, desires position with opportunity. Capable of handling men.

G-200 Mechanical engineer, technically educated, age 30, married, one and one half years shop experience and ten years practical experience in engineering departments of large concerns manufacturing valves, steam and engineering specialties well versed on power plants; executive ability.

G-201 Mechanical engineer with broad designing experience of steam pumps, open for position as draftsman, hav-

ing held similar position for years with a leading pump concern; best references.

G-202 Student member, age 22, graduate M.E. at Washington University; experienced in drafting, and in oil and cement testing; served time as special apprentice with large company manufacturing iron and steel products; testing or designing; middle west preferred.

G-203 Member, technical graduate, age 32, having two capable associates and centrally located office, will take additional representation in Philadelphia for reputable manufacturer who has at present no direct representative. The character of the product must be such that a considerable business will be a result of thorough and systematic engineering salesmanship.

G-204 Student member, 1915 graduate; four years shop and erecting experience. Location immaterial; future prospects most important consideration.

G-205 Student member, M.E. Columbia University, desires employment with an engineering or manufacturing firm. Willing to start at low salary if there are chances for advancement.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A.I.E.E. and A.I.M.E. can be secured on request from Calvin W. Rice, Secretary of Am. Soc. M. E.

American Association of Demurrage Officers. Proceedings of 26th Annual Convention, 1915. Gift of Association.

American Wood Preservers' Association. Proceedings of 11th Annual Meeting, 1915. *Baltimore, 1915.* Gift of Association.

Carnegie Endowment for International Peace. Publication no. 1. Some Roads towards Peace. *Washington, 1914.* Gift of Carnegie Endowment, etc.

Carnegie Foundation for the Advancement of Teaching. Annual Report of the President, 1914. *New York, 1914.* Gift of Carnegie Foundation, etc.

Centrifugal Fire Pumps, E. E. Maher. Reprint from Armour Engineer, May 1915. Gift of author.

Cincinnati Water Works Department. Annual Report, 1914. Gift of J. A. Hiller.

The Competent Life, Thomas D. West. *Cleveland, 1905.* Gift of author.

Essays on the development of human ability as an aid in the betterment of labor. Should be read by all who are interested in the improvement of the working man. W. P. C.

Controlling the Cost of Electricity, Walter N. Polakov. Reprint from May 1915, Engineering Magazine. Gift of author.

Cranes and Hoists, Hermann Wilda, translated from the German by Chas. Salter. *London, 1913.* Gift of Hunt Memorial Fund.

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Teaches the doctrine of work in the development of efficiency in man, and the causes of inefficiency. W. P. C.

Exploitación del Petróleo de Comodoro Rivadavia. Memoria Correspondiente á los años 1912/13. *Buenos Aires, 1914.* Gift of R. R. Edgar.

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Massachusetts. Boiler Inspection Department. District Police. Steam Boiler Rules formulated by the Board of Boiler Rules. *Boston, 1915.* Gift of A. S. M. E.

Milwaukee (Wis.) Smoke Inspector. Annual Report, 1914. *Milwaukee, 1914.* Gift of Chas. Poethke.

New York State. Department of Health. Thirty-fourth Annual Report, 1913. *Albany, 1914.* Gift of State Department of Health.

Panama Pacific International Exposition, San Francisco, 1915. Official Swedish Catalogue. *Stockholm, 1915.* Gift of Commissioner General for Sweden.

Polytechnic Engineer. vol XV, 1915. *Brooklyn, 1915.* Gift of Polytechnic Institute of Brooklyn.

Purdue University. Alumni Register, 1875-1911. *Lafayette, 1912.* Gift of A. S. M. E.

Sanitary Disposal of Municipal Institutional and Industrial Waste. The Morse Destructor. *New York.* Gift of Jarvis-Morse Corporation.

Steam Boiler Explosions, W. H. Boehm. *New York.* Gift of Fidelity and Casualty Company.

Tables Annuelles de Constantes et Données Numeriques. Art de l'Ingenieur et Metallurgis. Extrait du volume III, 1912. *Paris, 1914.*

Données numeriques et l'electricité, magnetisme et electrochimie. Extrait du volume III, 1912. *Paris, 1914.* Gift of University of Chicago Press.

These two pamphlets are reprints from the Annual Tables of Constants of the Portions relating (1) to Engineering and Metallurgy; (2) to Electricity, Magnetism and Electro-chemistry, thus placing at the disposal of the student at a small cost the essential standards. W. P. C.

Test Methods for Steam Power Plants, Edward H. Tenney. *New York, D. Van Nostrand Co., 1915.* Gift of publishers.

In connection with a large amount of experimental work done by the author, he has consulted numerous authorities as to testing methods. The methods gathered together in this book are those which he has found most satisfactory in practice. W. P. C.

Valves and Valve Gears, Franklin D. Furman. Ed. 2. Volume I—Steam Engines and Steam Turbines. *New York, J. Wiley & Sons, 1915.* Gift of publishers.

The chief aim has been to tell in particular, instead of in general, just how the engine or motor is regulated; also to tell how the valves and valve gears may be laid out, with due regard to the laws of mechanism, to give desired control of the steam or gas or other operating agent. W. P. C.

EXCHANGES

American Railway Engineering and Maintenance of Way Association. Proceedings vol. 10, pts. 1-2. *Chicago, 1909.*

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North East Coast Institution of Engineers ane Shipbuilders Transactions. Vol. XXX. *Newcastle-upon-Tyne, 1915.*

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Webster Mfg. Company. *Tiffin, O.* Webster Method. *May 1915.*

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GIFT OF NATIONAL CHILD LABOR COMMITTEE

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TRADE CATALOGUES

Under-Feed Stoker Co. *Chicago, Ill.* Publicity Magazine, April 1915.

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American Society Testing Materials
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Registration of Engineers

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W. H. PAINE, *President;* ARTHUR H. ANNAN, *Vice-President;* J. A. BROOKS, *Secretary;* A. H. WHATLEY, *Treasurer*

OFFICERS OF THE STUDENT BRANCHES

INSTITUTION	DATE AUTHORIZED BY COUNCIL	HONORARY CHAIRMAN	CHAIRMAN	CORRESPONDING SECRETARY
Armour Inst. of Tech.	Mar 9, 1909	G. F. Gebhardt	J. M. Byanskas	E. S. Echlin, Armour Inst. of Tech., Chicago, Ill.
Carnegie Inst. of Tech.	Oct 14, 1913	W. Trinks	J. R. Cline	Julius Guter, 303 Dithridge St., Pittsburgh, Pa.
Case School of Applied Science	Feb 14, 1913	F. H. Vose	L. W. Hodons	Burton S. Dake, 1886 E. 75th St., Cleveland, O.
Columbia Univ.	Nov 9, 1909	Chas. E. Lucke	H. F. Allen	A. S. Henry, 333 Central Park W., New York, N. Y.
Cornell Univ.	Dec 4, 1908	R. C. Carpenter	A. R. Cota	W. F. Courtney, Telluride Assoc., Ithaca, N. Y.
Georgia Sch. of Tech.	Feb 13, 1915			W. T. McCullough, Jr., 55 W. North Ave., Atlanta, Ga.
Kansas State Agri. College	Feb 13, 1914	A. A. Potter	L. A. Wilsey	F. R. Rawson, Kan. State Agri. College, Kan.
Lehigh Univ.	June 2, 1911	P. B. de Schweinitz	C. H. Shuttler	W. C. Hartman, Lehigh Univ., South Bethlehem, Pa.
Leland Stanford Jr. Univ.	Mar 9, 1909	W. F. Durand	W. H. Warren	F. G. Hampton, 313 Kipling St., Palo Alto, Cal.
Mass. Inst. of Tech.	Nov 9, 1909	E. F. Miller	K. C. Richmond	C. E. Shedd, 74 Lakeview Ave., Haverhill, Mass.
New York Univ.	Nov 9, 1909	C. E. Houghton		

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Penn. State College	Nov 9, 1909	J. P. Jackson	H. L. Mummert	E. J. Kenney Pa. State College, State College, Pa.
Poly. Inst. of Brooklyn	Mar 9, 1909	W. D. Ennis	H. Brandt	Charles E. Rohmann Poly. Inst. of Brooklyn, Brooklyn, N. Y.
Purdue Univ.	Mar 9, 1909	G. A. Young	W. T. Miller	L. C. McAnley Purdue Univ., Lafayette, Ind.
Rensselaer Poly. Inst.	Dec 9, 1910	A. M. Greene, Jr.	C. P. Brown	W. Kelly 374 Clinton Ave., Albany, N. Y.
State Agri. College (Colo.)	Oct 9, 1914	J. W. Lawrence	A. T. Johnson	T. H. Sackett State Agri. College, Fort Collins, Colo.
State Univ. of Iowa	Apr 11, 1913	R. S. Wilbur	C. W. Harrison	Victor Johnson Cedar Rapids, Ia.
State Univ. of Kentucky	Jan 10, 1911	F. P. Anderson	M. Brooke	T. R. Nunan 345 S. Limestone St., Lexington, Ky.
Stevens Inst. of Tech.	Dec 4, 1908	Alex. C. Humphreys	F. F. Blixt, Jr.	R. F. Hohman Stevens Inst. of Tech., Hoboken, N. J.
Syracuse Univ.	Dec 3, 1911	W. E. Ninde	D. R. Hay	H. B. Tracy Fayetteville, N. Y.
Throop College of Tech.	Nov 13, 1914	W. H. Adams	R. O. Catland	H. A. Black 32 N. Grand Oaks Ave., Pasadena, Cal.
Univ. of Arkansas	Apr 12, 1910	B. N. Wilson	M. McGill	C. Bethel Univ. of Ark., Fayetteville, Ark.
Univ. of California	Feb 13, 1912	Joseph N. LeConte	A. C. Moorhead	H. L. McLean Univ. of Cal., Berkeley, Cal.
Univ. of Cincinnati	Nov 9, 1909	J. T. Faig	A. J. Langhammer	W. T. Lowell 309 Ludlow Ave., Cincinnati, O.
Univ. of Colorado	Apr 10, 1914	J. A. Hunter	E. B. Good	Wilfred Sawyer 970 11th St., Boulder, Colo.
Univ. of Illinois	Nov 9, 1909	W. F. M. Goss	R. C. Maley	E. B. Stout Univ. of Illinois, Urbana, Ill.
Univ. of Kansas	Mar 9, 1909	P. F. Walker	J. Stillwell	A. J. Nigg 1324 Vermont St., Lawrence, Kan.
Univ. of Maine	Feb 8, 1910	Arthur C. Jewett	W. L. Wark	H. A. Titcomb Phi Kappa Sigma House, Orono, Me.
Univ. of Michigan	Apr 10, 1914	John R. Allen	W. W. Tuttle	H. S. Manwaring 1666 Broadway, Ann Arbor, Mich.
Univ. of Minnesota	May 12, 1913	W. H. Kavanaugh	D. M. Giltinan	R. R. Boyles 1738 Grand Ave., St. Paul, Minn.
Univ. of Missouri	Dec 7, 1909	H. Wade Hibbard	L. L. Leach	I. O. Royse Albany, Mo.
Univ. of Nebraska	Dec 7, 1909	J. D. Hoffman	L. L. Westling	R. B. Saxon Univ. of Neb., Lincoln, Neb.
Univ. of Wisconsin	Nov 9, 1909	J. G. D. Mack	J. B. Wilkinson	G. C. Richardson Univ. of Wis., Madison, Wis.
Virginia Poly. Inst.	Jan 8, 1915	L. S. Randolph	R. C. Brauer	H. F. Watson Va. Poly. Inst., Blacksburg, Va.
Washington Univ.	Mar 10, 1911	E. L. Ohle	R. V. Henkel	E. C. Schisler Washington Univ., St. Louis Mo.
Worcester Poly. Inst.	June 16, 1914	W. W. Bird	Harold Nutt	H. P. Fairfield
Yale Univ.	Oct 11, 1910	L. P. Breckenridge	R. F. Frost	W. S. Snead 96 Wall St., New Haven, Conn.